NASA TECHNICAL TRANSLATION NASA TT F-16,214

SPACE: ROAD WITHOUT END

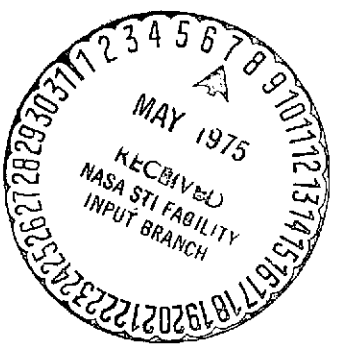
A.G. Nikolayev

Translation of Kosmos - Doroga bez Kontsa, Moscow, "Molodaya Gvardiya" Press, 1974, 270 pp

(NASA-TT-F-16214) SPACE: ROAD WITHOUT END (Kanner (Leo) Associates) 237 p HC $7.50 CSCL 22A

N75-21305

Unclas
G3/12 18676



NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
WASHINGTON, D.C. 20546 APRIL 1975

STANDARD TITLE PAGE

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
NASA TT F-16,214		

4. Title and Subtitle	5. Report Date
SPACE: ROAD WITHOUT END	April 1975
	6. Performing Organization Code

7. Author(s)	8. Performing Organization Report No.
A.G. Nikolayev	
	10. Work Unit No.

9. Performing Organization Name and Address	11. Contract or Grant No.
Leo Kanner Associates Redwood City, California 94063	NASw-2481
	13. Type of Report and Period Covered
	Translation
12. Sponsoring Agency Name and Address	14. Sponsoring Agency Code
National Aeronautics and Space Administration, Washington, D.C. 20546	

15. Supplementary Notes

Translation of Kosmos - Doroga bez Kontsa, Moscow, "Molodaya Gvardiya" Press, 1974, 270 pp

16. Abstract

Pilot-Cosmonaut of the USSR, Twice Hero of the Soviet Union, and Major General of Aviation A. Nikolayev recounts the training and preparation of cosmonauts for space flights, his second space flight on Soyuz-9, the activities of spacecraft crews in orbit, and the prospects for future space research. The last chapter deals with duties and responsibilities of a new profession -- pilot-cosmonaut.

17. Key Words (Selected by Author(s))	18. Distribution Statement
	Unclassified-Unlimited

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price
Unclassified	Unclassified	233	

Foreword

Every cosmonaut goes through his flight three times: one he is preparing for it, one he is actually on it, and finally, on Earth, when he sums up.

I have had the great honor to be twice assigned the piloting of a spacecraft. The first time was in 1962, when for 4 days I flew on Vostok-3, the second time, nearly 8 years later, was in 1970 when I was chosen commander of the crew of the Soyuz-9 spacecraft, along with flight engineer Vitaliy Ivanovich Sevast'yanov. Together we worked in orbit for 18 days.

It is about this flight, the second one, that I wish to tell the readers, comparing it with the first flight, and sharing my thoughts about the profession of a cosmonaut, in which young people are showing a steadily growing interest.

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SPACE: ROAD WITHOUT END

A.G. Nikolayev

PART 1. PRIOR TO LAUNCH

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Spring 1970. Vitaliy Ivanovich and I are flying to the space center from which we are to be launched into space on the Soyuz-9 spacecraft.

The weather was good at the space center. The day was clear and sunny, and the temperature (centigrade) was about thirty degrees. But we did not feel especially hot; a light breeze was blowing, and we breathed freely and easily.

I have been a cosmonaut for 10 years. I have had to be at the space center more than once. I have accompanied my comrades to their missions, and they have accompanied me. Everthing here is well-known and familiar. But at the same time, whenever I come here, I find something new. A space city is being built, is growing all the time. New houses spring up, and indeed, such houses -- entire city blocks. New streets are being laid out, more and more new schools, movie houses, stores, and hotels are being opened. The little town is clad in green: the streets are growing green, and public gardens are being landscaped.

Even though our space center is still new, nonetheless it already has its historic relics. Here they are -- two little houses not far from the launch pad: in one lived the Chief Designer, Academician Sergey Pavlovich Korolev; in the other, right beside the first, our planet's first cosmonaut -- Yuriy Alekseyevich Gagarin -- spent his last night before his launch.

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Now it is traditional for the cosmonauts to come here before their launch, to these little houses, in order to report, if only mentally, to Sergey Pavlovich and Yuriy Alekseyevich that we are ready for the mission, that everything is in order, that we shall fulfill our Homeland's assignment with honor.

Years and centuries will pass, but the nations of the world will never forget the achievement of our century, an achievement daring in conception, brilliant in execution, an achievement which demanded great courage and strength of will.

Each of our achievements in space is the sum of great, self-sacrificing labors on the part of a large team of scientists and

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* Numbers in the margin indicate pagination in the foreign text.

and designers, engineers, technicians, and workers -- all those who build the remarkable spacecraft, the earth satellites, and the rockets, all those who teach and train the cosmonauts for their missions, all those who keep round-the-clock watches at their desks in the ground control centers.

It can rightly be said that our achievements in this field are those of the entire Soviet nation. Every time we settle into the cabin of our spacecraft we feel the warmth of the hands of those who created these amazing machines; and in the operation of sophisticated instruments we hear the beating of the fervent hearts of those who created them.

Cosmonauts always remember and always will remember the eminent designer Sergey Pavlovich Korolev, who was twice a Hero of Socialist Labor, a Lenin Prize winner, under whose leadership the first space-rocket systems were devised.

We will never forget our friend and comrade, Yuriy Alekseyevich Gagarin, whose name all mankind associates with the beginning of the space era.

Everything that only can inform people about the life and work of S.P. Korolev and the achievement of Yu.A. Gagarin is sacred to us. Therefore, we are deeply grateful and thankful to all those comrades who preserved these two littel houses and reconstructed in them the surroundings of the days which accompanied the first space flight.

A visit to these houses always disposes one to remembrances. As I rested in the evening in a room in the new Cosmonaut Hotel, I could not fall asleep for a long time. There passed in front of me, one after another, pictures of that day when we helped Yuriy put on his space suit, when 6 months later I, who was Gherman's backup, slept on Yuriy's bed in this little house, and /5
when, finally, after yet another year, as I was preparing for my own launch on Vostok-3, I spent yet another night in it.

It all began this way. We, a group of wartime fighter pilots who had been chosen by special and very strict medical and mandate commissions, arrived in Moscow. Among us were the then-unknown Yuriy Gagarin, Gherman Titov, Valeriy Bykovskiy, Boris Volynov, Georgiy Shonin, Aleksey Leonov, Viktor Gorbatko, Yevgeniy Khrunov and other comrades. We were welcomed by Pavel Popovich, who had come to the capital city just ahead of us and who already felt like an "old-timer," our "host." He helped us get settled in our rooms and familiarized us with a schedule of our activities, with our lecture halls and with procedures.

Then, in 1960, the Cosmonaut Training Center, with its living quarters, study rooms, sports areas and auditorium, was located

on the central airport, not far from the "Airport" metro station. We later moved to the special Star City, which was being built and which was so named only after Yuriy Gagarin's mission.

Not wasting any time, we immediately began our activities. We assiduously begain to study theoretical disciplines, such as astronomy, celestial navigation, and space medicine, all of which were new but necessary to us. We not only learned the structure of spacecraft, but we also took part in the overall testing of their systems and equipment. We tried on the first space suits. We flew on special airborne laboratories and bailed out with our parachutes. Physical training took up particularly much of our time.

We were to meet more than once with the Chief Designer, Sergey Pavlovich Korolev.

I especially remember our first meeting with him, when he invited us to his office.

He personally greeted each one of us. Then he spoke fascinatingly about his design office, space rockets and spacecraft, and man's future missions into space. After our talk, he invited /6
us to the shops where the launch vehicles and spacecraft has been assembled. For the first time we saw not only a mockup or a simulator, but the actual spacecraft on which we were to fly and the launch vehicles which were to put these spacecraft in oribt. We were surprised and amazed by the scope of the construction of such miracle technology. We were filled with pride in the scientists, designers, and workers -- those who created space technology.

I will not conceal that it was very pleasant to have a certain inner feeling of joy; the time would soon come, when it would be we who were entrusted with testing this complex technology in space flight.

Sergey Pavlovich himself led us on our tour of the assembly buildings and huge halls where the spacecraft and launch vehicles stood. He showed us and explained in detail about everything. At the end of our tour we all stood next to the Vostok spacecraft. Sergey Pavlovich said, "Boys, the spacecraft has been made reliable in all respects. Here on Earth we do all the necessary testing of systems and equipment, and when we are one hundred percent sure of it, we will put it into space. Whoever among you is first to test this spacecraft in space, well, and afterwards other comrades will fly on later missions, and each new mission will be more complex and difficult. For this, it is necessary to train well."

As Sergey Pavlovich spoke, we absorbed each word, each gesture, capturing his every intent gaze. We understood him well and acknowledged the responsibility which lay on us.

At the end of our meeting, Sergey Pavlovich gave us each a replica of a pennant with the ensignia of the USSR on it, the pennant which we were to place on the Moon for the first time. We said goodbye to him and went home with shining faces. On the way there were many lively conversations about what we had seen and heard.

And again there were days of study, days of training on the training craft. We stubbornly and persistently did and redid all our exercises in controlling the spacecraft and its systems.

The more successful our creators of space techology were, the more intense our theoretical and training activities became. /7
Our training sessions on sports apparatus and on our training fields became more and more intense. No one then knew how the human body would behave in space, how it would react to acceleration as the spacecraft ascended and overcame the force of the Earth's gravity, how it would behave in prolonged zero gravity in orbit, and how it would endure the inevitable transition from zero gravity to renewed g-loads as the spacecraft descended to Earth.

The medical specialists justly considered that such is within the strength of only a well-trained man. And so we trained, trained and trained some more.

Finally the day came when we were to take our examination from the specialists in space technology. We were to demonstrate our knowledge of the spacecraft's systems, as well as our skill in controlling it.

It so happened that Yuriy Gagarin was the first to take the examination. He took his place in the spacecraft and answered the examiners' many questions literately and clearly. I was simply delighted at his answers, was glad for him, and was amazed at his resourcefulness, keen wit and imperturbability. Everyone liked his answers, and his knowledge was rated "excellent."

Then the others' turns came. We all demonstrated high knowledge during the examination, and we all received excellent marks.

In our joint training for the mission, even from the time we passed the medical section, Yuriy Gagarin was, as they say, first among us. He was always cheerful and comradely with everyone; he loved witticisms, anecdotes, songs; he was quick-witted, inquisitive, and never dejected. It was always happy and good to be with him. At the same time he had a very strong will and sense of self-discipline. We all found Yuriy's remarkable human qualities to our liking. If, in conversations among the cosmonauts, the question arose as to who would get the first

mission, we always declared that Yuriy should be first. His usual reply to this, "Well, boys, we're all equally ready for the mission; whoever gets it will get it."

We were very glad that our choice was no mistake: the /8
State Commission named Yuriy Gagarin commander of the first spacecraft, the Vostok, and German Titov his backup.

Yuriy and Gherman spent their last night before their launch in the now-historic little house.

In the morning all of us who had trained with Yuriy and Gherman for the first mission helped them on with their space suits. Then they got into a bus and left for the launch pad. On the way they sang songs, joked, and rejoiced at what lay ahead -- man's first launch into space.

Now the final handshakes. I embrace Yuriy strongly and want to kiss him as we part, but the pressurized helmet allows no kissing and indeed leaves a rather noticeable bruise, as if a "souvenir" on my forehead.

Yuriy said warm goodbyes to each of us and said, "Well, brothers, one for all, and all for one." These words became a rule of friendship among the cosmonauts.

Having reported to the Chairman of the State Commission about his readiness for the mission, Yuriy received permission to enter the spacecraft. Once again he said goodbye to us, then he went to the elevator and began slowly to ascend to the top of the launch vehicle.

From there, from the height, he again waved and entered the spacecraft through a hatchway.

When Yuriy had taken his place, we and the specialists at the command center began to maintain continuous radio communication with him.

All the while he felt good. His mood was cheerful. Understanding how everyone was worrying and going through it with him, he tried to cheer those of use who had stayed behind.

But we really were worried. After all, no one had ever flown into space before: somehow he will make it!

At last the command center called "Launch!" The rocket slowly moved from its place. And then we heard Yuriy exclaim, "Let's go!"

We ecstatically joined in, "He's on his way, he's on his way!" And we all shouted "Hurrah!"

As we flew to Yuriy's landing site, we heard the TASS communique about the successful completion of man's first space flight. /9

We were pleased to know our small labor had gone into this great enterprise.

We flew to where Yuriy had stopped for a short while for a preliminary postflight examination. When the boys and I appeared in the doorway, Yuriy rushed over to us. There was great joy; it was a great day for all of us. Yuriy, seeing the bruise on my forehead, perplexedly asked where I got it. I laughed, "This is a souvenir of your launch, the mark from your helmet."

Finally, we all calmed down. Yuriy told us in detail about all he had seen and experienced, about how he had borne the acceleration, the vibrations, the weightlessness. In conclusion he said, "A man in a spacecraft can live and work normally in outer space."

With his flight he opened humanity's way into space.

* * *

After a careful analysis of the first mission, a new mission on Vostok-2 was prepared and carried out less than 6 months later.

Gherman Titov was named commander of this spacecraft, and I was to be his backup. I was glad beyond measure at the trust shown in me.

Gherman and I trained for the Vostok-2 mission thoroughly and very painstakingly. Although Yuriy Gagarin had proved that a well-trained man can live and work in space, endure the acceleration and weightlessness during a flight of a single orbit, a great many questions confronted Vostok-2.

Here was one: Yuriy's flight lasted 108 min, but how would a man feel on a longer mission, one of, say, 24 hours?

Gherman was to answer this question.

Gherman and I spent prelaunch eve in the cosmonauts' house, where he, as Yuriy's backup, had already spent a night once before. When we went in, Gherman lay down on "his" bed, where he had slept the night before Gagarin's launch, and suggested that I take Yuriy's place.

Yuriy's portrait already hung above "my" bed. There was a table in the middle of the room, and on it, a vase full of wonderful flowers -- the work of Aunt Klava's attentive housekeeping. /10

A chess set, newspapers and magazines were spread about. On the right, on a night table, was a radio; on the left was a sofa. We settled comfortably on the sofa, once again read through the logbooks, and talked about tomorrow's launch. Before going to sleep, we went out for a stroll. Sergey Pavlovich met us here. He had just come from the launch pad, where the Vostok-2 was being readied for launch. He told us briefly that all operations were proceeding normally and according to schedule. "Everything will be all right, don't worry, boys, and sleep well."

He talked a bit more with us and then went back to the launch pad. I through, "Gherman and I are calm, but here is Sergey Pavlovich, no, it was not noticeable in his appearance, but all the same I felt that he was worried for us, that he was living through it with us."

Before going to sleep, while already in bed, Gherman began to recite Eugene Onegin from memory," My uncle was always respected..." But he had not reached the end of the first chapter when our physician, Andrey Viktorovich, who had heard Gherman's voice, came in and sternly admonished him, "You should sleep!" There was nothing to do but admit it. We fell silent at once and soon fell asleep.

The alarm clock woke us. We quickly did light calisthenics, went through a medical check, ate breakfast and began, with the help of our comrades, to don our space suits.

At the space center, while saying our farewells, Gherman said to me, "Andrey, don't fell bad, your launch day will come soon, be happy."

I said goodbye to Gherman, wished him bon voyage and as backup stayed in the bus until it was announced that the count-down as at 1/2 hour. I then undonned the space suit, went out to the observation point, and along with everyone else, watched Gherman's launch and rejoiced for him. When his spacecraft had entered orbit, we went out with the recovery team to where he would land.

Twenty-four hours passed. On August 7, Gherman landed safely. We had a joyful reunion at the landing site. I gave him my heartfelt congratulations on this 24-hour flight. There was /11
much joy, and there were many interesting conversations. When I asked Gherman what had been most important in his mission, he answered without hesitation, "Andrey, it is necessary to train the vestibular apparatus." His advice proved very helpful to me, and while training for the Vostok-3 mission, I paid particular attention to training the vestibular apparatus -- in the morning during gymnastics, in my physical fitness activities, and on the special simulators.

The result of the first two missions, an analysis of the cosmonaut's work capacity in zero gravity, and an analysis of the operation of the spacecraft and its systems allowed us to take the next step in space research: a joint, extended flight of two spacecraft.

Pavel Popovich and I were named commanders of Vostok-4 and Vostok-3, respectively. My backup was Valeriy Bykovskiy, and Pavel's was Vladimir Komarov. Yuriy and Gherman gave us great help while we were training, both with their advice and with their experience.

This seems naive now, but then the medical specialists and scientists long debated how many days the Vostok-3 and Vostok-4 missions should be. Some said that it was necessary to repeat the 24-hour flight, with the possibility of extending it to 3 or 4 days if the cosmonauts felt good. Sergey Pavlovich proposed a mission of 3 or 4 days right away, with the possibility of landing the spacecraft any day the cosmonauts wished. We -- the commanders and our backups -- supported the reasonable suggestions of our Chief Designer, and the State Commission accepted it. Lengthening the flight was a great step forward in studying and opening up space.

Yuriy, Gherman, and our backups -- Valeriy and Vladimir -- escorted me, and after 24 hours, Pavel, to this longer mission. At our farewell, the boys said many warm parting words to me. Gherman leaned close to my helmet and said, "Well, Andrey, your day has come. I wish you a successful launch, flight, and landing." I thanked him sincerely and turned to the Chairman of the State Commission. Having received permission to carry out the mission and having taken my leave of him, Sergey Pavlovich, and my other /12
comrades, I went up to the elevator site. Here, with precisely the same gesture as Yuriy and Gherman had made -- this became our tradition -- I bade goodbye again to those who had escorted me, and then I entered the elevator which took me up to the cabin of the Vostok-3.

I have told in detail of my impression of my first space flight in my book Vstretimsya na orbite [Let Us Rendezvous in Orbit]. Here I will mention only that our joint flight introduced much that was new to space flight organization. It demonstrated the great precision with which Soviet specialists could consistently insert launch vehicles into orbit. This gave us reason to think that the technology of these rendezvous could be developed, which in turn meant that it would soon become practically possible to have not only a joint flight, but also a rendezvous and docking of spacecraft, as well as to build space stations in orbit.

The joint flight of two Soviet spacecraft also demonstrated that reliable two-way radio contact between two spacecraft in

space was possible and confirmed the high quality of radio and television communcation with ground control stations.

During the mission we did a series of experiments in zero gravity. The most crucial and interesting was an experiment in getting our of the seat and free-floating about the cabin for an extended period of time.

I was outside the seat belt system for 4 hours during 4 days, and Pavel Popovich for about 3 hours during 3 days. As we floated inside the cabins, we made observations and carried out special experiments. During the free-floating and throughout the mission, we felt good and did not experience any unpleasant sensations or disorders. In general, everything was normal.

But here is how Yuriy described our flight in his notes: "According to the schedule worked out earlier on Earth, the time approached for Andrian Nikolayev to leave his pilot's seat. As is known, neither I nor Gherman Titov had done this. Naturally, we all waited for this moment impatiently and watchfully. After all no one knew what could happen to the cosmonaut when in zero gravity he freed himself from his seat belt system and began free-floating. Could he return to his seat without any help? On Earth a series of recommendations had been made to the cosmonaut: first free the left shoulder from the seat belt system, then the right shoulder, and, making no sudden movements, try to move away from the seat. Andrian did this. He revealed that a man who was weightless could move freely about the spacecraft." /13

Our appraisal of the consumption of water and food, our discovery of the peculiarities of taste sensations, our research on the influence of prolonged weightlessness on respiratory metabolism (man's consumption of oxygen and discharge of carbon dioxide) were of no little scientific interest. Solving these questions allowed us to go on to devise more rational means and methods for the life support of the crews of future space flights.

* * *

Even before the launch of the Vostok-3 and Vostok-4, a group of young women joined our group of cosmonauts. They were to take the full course of cosmonaut training for the execution of a mission. Toward June 1963, they completed this course. After our flight, Pavel and I, just as Yuriy Gagarin and Gherman Titov had done for us, helped the women to train for launch. We shared our experience with them, we helped out with our advice and example during training. At the same time the women were training, Valeriy Bykovskiy and his backup, Vladimir Komarov, were training for their flight on Vostok-5, and we did not forget our boys, helping them as we did the women.

Now it was not the usual, strictly male crew that went out to the launch pad, but a mixed crew. To us men, it somehow all became more cheerful and gay. Our songs sounded prettier and richer with women's voices added.

The day of Valeriy's launch came, and 2 days later, that of Valentina. Yuriy, Gherman, the other cosmonauts and I lived through it with our friends, and of course for Valentina more especially. This was as it should be. Valeriy would endure everything as if it were easy; after all, he as a man, a fighter pilot. But Valentina -- she was a woman! /14

But her resonant feminine voice and her distinct call signals from space -- "This is Seagull! This is Seagull! I feel fine" -- reassured us.

When Valeriy and Valentina successfully landed after their missions, this was a most joyful and grand holiday for us all.

I want to add one more thing: in the United States in 1963, as part of the NASA program, two women, Jean Hart and Jerry Cobb, were also training for a space flight.

Soon after Valentina Tereshkova was launched, Jerry Cobb admitted that she was "very disappointed" that a Russian, not American, was the first woman in space. Jean Hart announced with sadness that NASA would evidently continue to be skeptical about women astronauts, "even if the Russians shoot the entire Leningrad symphony into space and then bring it back."

The Soviet program of space flights in one-man, manned spacecraft was completed with the Vostok-5 and Vostok-6 missions.

Now a new, multi-manned spacecraft, the Voskhod, was being prepared for launch. Its crew consisted of three: The commander, Vladimir Komarov; the flight engineer and Candidate of Technical Sciences, Konstantin Petrovich Feoktistov, and a physician, Boris Borisovich Yegorov. This was the first multi-manned spacecraft in the world, and for the first time men who were both cosmonauts and scientists -- an engineer and a physician -- were launched into space with a pilot-cosmonaut.

This mission was very interesting and was filled with various experiments.

The Voskhod mission carried out many experiments in engineering. The large amount of work the crew had to do was connected with the making of navigational observations: they measured the height of the stars and other celestial bodies above the Earth's visible horizon, and they identified certain landmarks on Earth.

On this mission, purposeful observations were made for the first time of the Earth's cloud cover, and the optical characteristics of different parts of the Earth's surface were measured. Konstantin Petrovich Feokistov did this. /15

Boris Borisovich Yegorov, the physician, examined the physiological functions of the cosmonauts, monitored their blood circulation in zero gravity conditions and studied the work capacity and the motor coordination of the crew members. He took blood samples for analysis as well as samples of the air the cosmonauts breathed out.

The spacecraft commander, Vladimir Komarov, did experiments as specified in the research program. On this mission he was not simply a pilot, but also the commander of the crew of the multi-manned Voskhod spacecraft.

Yuriy Gagarin and I were assigned to keep in constant communication with the Voskhod crew. We were on duty in the communications control center, and we noted with pleasure how harmoniously and smoothly the crew worked together.

The complexity and significance of our experiments in space grew step by step. Four years after Gagarin's launch, man for the first time left the spacecraft and walked in space. Aleksey Arkhipovich Leonov, dressed in a special space suit, opened the "door" of the spacecraft on Voskhod-2's second orbital phase, and, pushing himself away from the craft, walked out into space -- into the silent, black abyss. He floated in the void. He saw the Earth, the stars, the Moon, and the planets, not through the window of the spacecraft, but through the transparent helment of his space suit. He could look at his spacecraft from the outside, he could "touch" the airless space, and he could directly apprehend the marvelous world of space. While on his space walk, he successfully made observations, did assembly operations, and successfully reentered the spacecraft. Voskhod-3's commander, Pavel Ivanovich Belyayev, was in direct command of the preparation for the exit itself, and the operations outside the spacecraft.

Before this mission, some thought that the immensity of space would evoke fear in man, that the human psyche could not bear this fear, and that this could be a real obstable to man's conquest of space. /16

But P. Belyayev's and A. Leonov's mission proved it fully possible to work outside the spacecraft in space itself. This means that in the future, when large space stations and laboratories are assembled from parts in orbit, the cosmonauts who assemble them will leave the cabins of their spacecraft and go out into space, gather the parts together, and weld them together in a single entity.

* * *

The Voskhod spacecraft was an intermediate step between the one-man Vostok and the multi-manned, multipurpose Soyuz spacecraft.

This new spacecraft was an important step forward for those who created space technology. In their conception, it could, as the cosmonaut pleased, perform complex maneuvers in orbit, dock with other spacecraft, and serve as the means of communication between Earth and a long-term space station in orbit.

To test this new spacecraft and to conduct scientific research in space, a large group of cosmonauts was formed, a group which included Yuriy Gagarin, Vladimir Komarov, Aleksey Yeliseyev, other cosmonauts and me.

We avidly began studying the new spacecraft. At the beginning of April 1967, everything was ready for the test. The State Commission gave the first Soyuz mission to Vladimir Mikhailovich Komarov, Hero of the Soviet Union and Aviator-Cosmonaut of the USSR.

During the test flight, Vladimir Komarov maneuvered the spacecraft, tested its basic systems in various modes, and certified its various technical capabilities.

On April 24, 1967, the research program was completed. After performing all the operations connected with the transition to a landing mode, Soyuz successfully passed through the most difficult and crucial stage: that of braking in the dense layers of the atmosphere and fully damping circular velocity. /17

But then something unforeseen happened. The parachute system failed on landing. Vladimir Mikhailovich Komarov, a talented test pilot, a bold and courageous man, a communist, died tragically.

Our long-awaited joy turned into great sadness and grief. The untimely death of a remarkable man, our friend, an engineer and test pilot of spacecraft, Vladimir Mikhailovich Komarov, was a great loss for our nation and for all mankind.

Through his work in testing spacecraft, V.M. Komarov, twice Hero of the Soviet Union, had made invaluable contributions to the development and improvement of space technology. His name will always serve as an example of heroism, bravery, and courage, and will summon us to new exploits in behalf of our great country.

* * *

A little more than a year passed. In October 1968 the flight tests of the Soyuz spacecraft were resumed. The State Commission entrusted this complex and crucial mission to the worthy aviator-test pilot of the USSR, a soldier and pilot, a participant in World War II, Hero of the Soviet Union, Georgiy Timofeyevich Beregovoy.

The research program called for a simultaneous flight of two spacecraft, one manned, the other unmanned.

On October 25, 1968, Soyuz-2 was put into orbit. After 24 hours, as it passed over the space center, Soyuz-3, manned by Georgiy Beregovoy, was launched into orbit. After it had entered orbit, G. Beregovoy rendezvoused with the Soyuz-2; automatic controls brought his spacecraft to a distance of 200 m from the other spacecraft. Then, using manual controls, Beregovoy twice approached the other spacecraft as near as a few meters. After completing their joint experiments, the Soyuz-2 landed. But the Soyuz-3 continued its missions, during which G.T. Beregovoy checked the various modes of the spacecraft's orientation; carried out a great deal of scientific and technical research, including observations of the starry heaven, the Earth's surface, photographing its cloud and snow cover, its day and twilight horizon, typhoons and cyclones; and did biomedical tests. He also gave a television report from orbit. /18

All this time my comrades and I were in the mission control group. We were in continuous contact with Georgiy and issued the necessary commands and recommendations with regard to the execution of the flight program.

A day before his landing, my comrades and I flew out to take part in the recovery operation of the Soyuz-3 after it landed.

Here at the control and tracking station, a bright dot appeared on the radar screen -- it was the Soyuz-3. The bright dot came rapidly nearer. It crossed the Caspian Sea, passed over the Kara-Kumy and neared Karaganda. We received the radio operator's message, "The parachute has opened." The bright dot hung on the screen, and as it came down to Earth, its velocity slowed.

After the parachute opened, an airplane and helicopter went out to meet the descending Soyuz-3, and the reports from their pilots came into the command post (to us): "I see the spacecraft." "The parachute has opened normally." The same report came in from the helicopter pilot. Everything is normal. But the crucial part -- the soft landing -- is still ahead. The time drags on slowly, and we feel as if it had stopped completely.

We wait for the next reports from the pilots: "The spacecraft has made a soft landing." We congratulated each other on the completion of the mission.

A half hour later, a helicopter brought Georgiy to the airport and then to a little house for a preliminary medical examination.

He took a bath right away, shaved, and changed clothes. They then served him an Earth lunch. After eating space food, we of course always ate with great relish when back on Earth. Georgiy too ate lunch, an Earth lunch, a real lunch.

But the correspondents -- the cosmonauts' constant companions -- were already waiting for him. Georgiy had to satisfy their request and give an interview about his mission.

Then we flew to Moscow.

* * *

Three months had not yet passed when a remarkable new page was written in the chronicle of space feats. /19

In order eventually to build a large space station and put a working group of researchers on it, it was necessary to solve the problem of rendezvousing and docking spacecraft in orbit.

On January 14, 1969, the Soyuz-4, manned by the aviator-cosmonaut Vladimir Aleksandrovich Shatalov, was put into orbit. On January 15, the next day after the launch of the Soyuz-4, the Soyuz-5 was put into orbit. Its crew included the commander, Boris Valentinovich Volynov, the flight engineer, Aleksey Stanislavovich Yeliseyev, and the research engineer, Yevgeniy Vasil'yevich Khrunov. During this joint mission, they carried out a very complex scientific and technical experiment: on January 16, 1969, the spacecraft, under automatic guidance, rendezvoused to a distance of about 200 meters. Vladimir Shalatov and Boris Volynov then switched over the manual control, completed the final approach, and moored the spacecraft together. The two spacecraft were mechanically captured, mated, and their electical circuits were connected.

So, for the first time in the world, an experimental space station was assembled in the orbit of an artificial Earth satellite, and it operated for some time.

While the spacecraft were docked, Aleksey Yeliseyev and Yevgeniy Khrunov donned their space suits and went outside the cabin into space. They made an outside inspection of the docking fitting and tested the capability of doing assembly operations outside. They were outside the spacecraft together for about an hour. Then they went into the second spacecraft, the Soyuz-4. They then did experiments in orienting and guiding the orbital station, and they checked the interaction of the on-board systems.

The Soyuz-4 and Soyuz-5 were docked about 5 hours, after which they were undocked; they then went their separate ways. During the mission the crews performed manual orientation of the spacecraft and corrections of their orbits; they conducted scientific-technical and biomedical research, as well as observation of /20
geological and geographical objects on the Earth's surface and celestial bodies; and they made navigational measurements, television reports, and took motion pictures and photographs. On January 17, 1969, after completing its research program, the Soyuz-4 spacecraft and its cosmonauts V.A. Shatalov, A.S. Yeliseyev, and Ye.V. Khrunov made a soft landing. The Soyuz-5, with B.V. Volynov on board, continued its mission another 24 hours; on January 18, 1969, it landed.

* * *

Yet another step into the future was taken in October 1969. A whole squadron of manned spacecraft carried out a simultaneous joint mission. For the first time three spacecraft were in orbit at once. Their crews included pilots, engineers, and scientists: Georgiy Stepanovich Shonin, Valeriy Nikolayevich Kubasov, Anatoliy Vasil'yevich Filipchenko, Vladislav Nikolayevich Volkov, Viktor Vasil'yevich Gorbatko, Hero of the Soviet Union Vladimir Aleksandrovich Shatalov, Aleksey Stanislavovich Yeliseyev. They were a harmonious team, and they carried out a sophisticated research program.

During this joint mission, a whole set of scientific experiments in near-Earth space was done simultaneously: the checking and testing of the structure of the Soyuz spacecraft; a further refinement of the manual control systems; orientation and stabilization in orbit; testing of the autonomous navigation instruments; and joint maneuvering of spacecraft (30 maneuvers in orbit!) with the goal of solving a series of problems on developing manned space systems.

Our ground stations during this time worked on their methods of controlling a joint mission of three spacecraft at once. While the spacecraft were being maneuvered, more than one change was made in their orbital parameters; the spacecraft also rendezvoused with each other, flew together within visual range of each other, and then parted.

A unique scientific and technical experiment done during the mission was experimental welding in space. A "Vulcan" welding /21
machine had been placed on the Soyuz-6 with this aim in mind. The welding was done using several methods: a low-pressure arc (plasma), an electron beam, and a consumable electrode. The welding was done automatically, by remote control, by our "space welders," Valeriy Kubasov and Georgiy Shonin. This experiment opened the way for welding and assembly operations in space.

* * *

Again, scientific thought; inquiring. Scientists knew that space was, to put it mildly, an environment ill-suited to life. Many well-known and unknown dangers lie in wait for those impudent and bold enough to leave the Earth's atmosphere: the closed environment, the limited size, the "poverty" of sounds, the remoteness from Earth, and the almost complete vacuum outside the spacecraft, a vacuum pierced by treacherous cosmic radiation. But the primary unknown was weightlessness. The scientists established that weightlessness was one of the most important factors in space flight, one which could cause various changes in the human body. After the first few years of the space era, we knew a great deal about this. But until then the length of the flight had been measured in days. How would this factor appear during longer flights, for example, of 2 or 3 weeks, a month, several months, years? After all, flights of this duration would invariably take place in the very near future.

So, the duration of the next space mission was set at 18 days.

A special group of cosmonauts was formed, and it began to train for this mission. I was in this group.

* * *

Eight years passed between my first space mission on the Vostok-3 and my second mission, this on the Soyuz-9.

Was this many or few? I deliberately pose the question.

It was of course only a few -- an older person would say. /22

The tempo of space research is such that in the 8-10 years after Yuriy Gagarin's mission, men were launched into space about 40 times. They flew around the Earth and the Moon; hundreds of Earth satellites served science; and unmanned interplanetary explorer satellites journeyed to Mars, to Venus, and made a soft landing on the latter's surface. The Luna-16 brought Moon soil back to Earth, and a lunar module pioneered lunar routes for almost an entire year. This was 8 years, clearly no small period of time.

In the years that had passed, space exploration had taken a great step forward into the limitless reaches of the universe. Space technology absorbed the best that modern science and technology could give it. The Soviet people, under the leadership of the Leninist party, made great progress in building a national economy -- in economics, science, technology, culture, and in strengthening our Homeland's defense capability. With each year

the standard of living of the Soviet people has risen. As never before the friendship and cooperation of the fraternal socialist nations has been strengthened.

During these years, great changes occurred in my life and in those of my comrades.

My comrades and I studied in the Air Force Engineering Academy imeni Professor N.Ye. Zhukovskiy, and I graduated in 1968. I took part in the training of cosmonauts for new space missions and in the direction of these missions.

To our great misfortune, we had heavy and irreplacable losses in these years. Volodya Komarov died while testing the Soyuz-1. Yuriy Gagarin's dream of being in space once again did not materialize. His life ended unexpectedly during a practice flight on an airplane. He died at his post. We lost the first man in space, a remarkable fighting comrade and friend.

Yuriy Gagarin's courage, his accomplishments, and his enthusiasm were a genuine school for us all, a real foundation for further accomplishment. He will always live among us, he will always be with us.

Pavel Belyayev died after a serious illness. Sergey Pavlovich Korolev, the eminent designer, also died. We survived our losses with difficulty. But all the same, life goes on. /23

During the years that went by, the boys who had entered the Center for Cosmonaut Training at the same time as Yuriy made further space flights.

Like other cosmonauts, I was fortunate enought to be a delegate to, and a participant in, our historic 23rd and 24th Party Congresses: the Soviet people elected me three times a deputy of the Supreme Soviet of the RSFSR: and I was delegate to the 15th and 16th Komsomol Congresses.

There were many meetings with workers, employees, kolkhoz farmers, students, schoolboys and girls; and there were more than 20 trips abroad.

Valentina Vladimirovna Nikolayev-Tereshkova graduated with distinction from the Zhukovskiy Military-Aviation Engineering Academy during these years. She was a delegate to the 23rd and 24th Party Congresses. At the 24th Party Congress she was elected a member of the Central Committee of the CPSU. At the 16th Komsomol Congress she was elected a member of the Central Committee of the Komsomol. Twice she was elected deputy to the Supreme Soviet of the USSR. Like all the cosmonauts, she had many meetings with workers, schoolchildren, and university students. She visited more than 30 foreign states.

In 1968, Valentina was elected chairwoman of the Committee of Soviet Women.

Valentina and I had a daughter, Alena; in 1971 Alena entered first grade in school.

Yes, time moves inexorably forward.

These years brought me closer to my comrade on the Soyuz-9, Vitaliy Ivanovich Sevast'yanov.

In 1960, as the cosmonauts began training for the historic first space mission, Yu. Gagarin, G. Titov, P. Popovich, V. Bykovskiy, A. Leonov, my other comrades, and I studied the theoretical and practical disciplines necessary to a cosmonaut.

One of our many instructors was a young and well-built man, Vitaliy Ivanovich Sevast'yanov, a specialist who knew his subject well. He came to our Star City (there was no town as such then, only a few little houses) from the design office to give lectures /24 on the mechanics of space flight.

Our first acquaintance with Vitaliy Sevast'yanov was in his first lecture. Like all our teachers, he spoke briefly about himself, and at once go down to business. He acquainted us, in general outlines, with his course of lectures and gave his first study assignment. Vitaliy Ivanovich somehow knew how to get the attention of his cosmonaut-students right away, even though he was still a rather young specialist. He gave excellent lectures: to-the-point, given with feeling, and he instilled in us a love for his subject. After his lectures, he often stayed with us, and in our free hours he helped us to master his subject better.

All the cosmonauts had good notes in his subject. For example, among all my other notes, I still have my notes on the mechanics of space flight. At the end of his course of lectures all the boys had marks of "excellent" or "good" only.

Vitaliy Sevast'yanov and I immediately developed good relations; in a little while, they turned into real friendship.

Vitaliy Sevast'yanov was born in Krasnouralsk in 1935. In 1953, he graduated with distinction from the Sochi Secondary School No. 9 imeni Nikolay Ostrovskiy.

He loved the sea, and during his school vacations, he worked as a sailor on a cutter which plied the Sochi-Khosta route. He handled the mooring lines, scrubbed the decks, and dreamed of becoming a ship-builder.

He told me about his love for the sea and ships in a very interesting and detailed way. But life offered him something else. He enrolled as a student in the aircraft construction department of the Aviation Institute imeni Sergey Ordzhonikidze in Moscow.

In 1969, Vitaliy finished his studied at the Institute and received his credentials as an engineer. He then began to work in one of the design offices. At the same time, he was a graduate stuent at the Moscow Aviation Institute. In 1965 he successfully defended his dissertation and thus became a Candidate in Technical Sciences.

He was very much taken with the problem of launching an artificial Earth satellite, he drew up designs, and he made plans. But the first Earth satellite had already been inserted into orbit without his participation. /25

Vitaliy Sevast'yanov diligently trained himself to achieve the goals he had set. He requested that he be admitted to the ranks of the cosmonauts. His health was good, he was knowledgeable, and he passed a strict selection committee without any bad marks.

Vitaliy, now a cosmonaut, trained persistently and diligently along with the other boys for the missions which lay ahead.

On April 20, 1969, it was proposed that Vitaliy Ivanovich and I be together on one crew and train for the Soyuz-9 space mission. This was a happy and joyous event for us both.

* * *

How much time is needed to train for a space launch? A year, two? Or perhaps longer?

This question can hardly be answered with precision. Each of my comrades got to the cabin of a spacecraft in his own way. For some, this took a little over a year. For others, it took several years.

The intricacy of the space rocket complex and the flight equipment, the increasing length of the missions, and the full program of research and experimental problems and operations -- all this makes exceedingly high demands on the cosmonauts and their training.

However, the long training period for several cosmonauts does not at all mean that some of us are more capable and can master everything in a short period of time and that some of us cannot. This is an oversimplified view.

A great deal depends on the general program of space research and on the technical capabilities of implementing it.

The launch of a manned spacecraft is a highly complex matter. Each launch is done when not only the crew but also the technology are ready for it, and when the program of a new experiment that will soon represent a new step forward in the development of space science, space technology, and space research has been elaborated. /26

The training of a cosmonaut is set up in such a way as to give each one a firm theoretical knowledge; to inculcate the skils in using and controlling the spacecraft, their systems and equipment; to impart the knowledge of how to overcome numerous difficulties; to condition them physically; and to instill in them a feeling of comradeship and mutual assistance, as well as high moral, psychological, and will-power qualities.

Pilots have a good saying, "If a pilot begins a mission thinking that he will perform a great exploit, then he is not ready for the mission." This is quite true, and, in my opinion, it is true for cosmonauts as well.

Training for a space mission is day-by-day, painstaking, and difficult intellectual and physical work. The cosmonauts consider it the most important and crucial stage -- since their ability to carry out the flight program depends on it -- and they do everything possible (and at time, it would seem, even the impossible) to train thoroughly for the performance of the entire flight program.

The cosmonauts' training is divided basically into two stages. The first is a general training program for everyone, where the cosmonauts receive the ncessary minimum of knowledge in space science and technology, astronomy, and space medicine; make training flights on airplanes and do parachute jumps; and do general-physical training and special biomedical training (training the vestibular apparatus, etc.).

The second stage is a training program specifically for an upcoming mission. For example, the training for the extended space mission on the Soyuz-9 included engineering and technical training: theoretical and practical study of the Soyuz-9's design and that of its launch vehicle; instruction in how to use and control the spacecraft -- this was done on specialized and sophisticated simulators; the improvement of skills in aviation and parachute-jumping; biomedical training of the human body, so as to increase it compensatory capabilities of enduring the impact of prolonged space flight; as well as psychophysiological training. /27

I shall try in as much detail as possible to tell about all aspects of the cosmonauts' space flight training.

* * *

During our engineering and technical training, we received the basic theoretical knowledge and practical skills needed in order successfully to control and test space technology while on the mission.

The engineering and technical training provided for the study of the design of the Soyuz-9 spacecraft, all its systems, the logic of its guidance system and its scientific and technological equipment; for familiarity with the methods of scientific research and testing; for a knowledge of the launch vehicle's design, ballistics, and flight dynamics.

It should be said that the spacecraft and the launch vehicle were quite complex and intricate (for the time) engineering designs.

In point of fact, if, let us say, a modern supersonic passenger airplane flies at about 2800 km/hour, the spacecraft enters orbit at a velocity that is almost 10 times greater -- 28,000 km/hour!

The launch vehicle imparts this velocity to the spacecraft. The power of the launch vehicle's rocket engines is in the tens of millions of horsepower! Just imagine: this is the power a large electric power station generates for a large city. I mention only for the sake of comparison that the power of the motors of a supersonic airliner is 250,000 hp, i.e., hundreds of times smaller.

However, this most powerful "machine" -- the launch vehicle -- has a surprisingly simple design.

One of the important launch vehicle characteristics is the relationship of the weight of the propellant to the weight of the entire rocket. The weight of an empty rocket together with its propulsion systems does not exceed 10-12% of the weight of the entire rocket. The remaining 88-90% is the weight of the propellant. /28

I cite a graphic example. A pail filled to the top with water has approximately the same weight-ratio, i.e., the weight of the empty pail is about 10-12% of the weight of the same pail filled with water.

But the launch vehicle can hardly be compared to an empty pail! The lauch vehicle comprises intricate propulsion systems,

pumping assemblies, automatic flight control systems, special devices to separate the rocket stages, etc.

Yet with all this the launch vehicle is still a very strong structure, which can endure the great dynamic strains associated with overcoming the forces of air resistance, acceleration, and the vibrations from power rocket engines.

The rocket's dimensions? Even our first launch vehicle, the Vostok, for example, was 38 m tall together with the spacecraft. This is the equivalent of a 12-story building; after all, the more powerful the rocket, the larger its size.

Now let us consider the spacecraft. In essence, it is a small planet. The spacecraft in its orbit revolves around the Earth; inside it, people -- cosmonauts -- live and work. They breathe, they eat, and they drink water.

When the flight is relatively brief, water, oxygen, and food in sufficient quantities must still be taken along. And if the missions last years at a time?

If one considers how much air a person breathes during 24 hours, how much water he uses in a day, a month, or a year, or how much food he eats, it at once becomes clear that no spacecraft can take all these along with it.

This means that it is necessary to provide the spacecraft with special devices that recycle the materials that man's vital activity produces and put them back into circulation.

Yet we have still not achieved a complete circulation of substances, or, as the scientists say, a complete ecological recycling. Nevertheless, a spacecraft is an inhabited planet, although, to be sure, the lives of its "inhabitants" are sustained for a comparatively short period of time. /29

But this is still not all: the spacecraft is not simply a place where cosmonauts live; it is also a scientific laboratory, designed to carry ou many tests and experiments in space. Consequently, it is equipped with many instruments and devices.

A spacecraft is also a flying machine. It maneuvers in space, and consequently it has flight control mechanisms, i.e., propulsion systems.

Finally, the spacecraft is provided with radio and television equipment for communications with ground stations.

I will describe in detail the structure of the Soyuz-9 spacecraft. But it seems to me that I have mentioned enough for

my readers to have some idea about the great intricacy of its design. We cosmonauts have to know the spacecraft's structure in detail, all its assemblies, and not only know them, but also know how the use them and how to remove malfunctions whenever they occur.

Navigational training. Space navigation in the broad sense of the term has to do with controlling the motion of the spacecraft.

Here it seems necessary to clear up several questions about space navigation.

The cosmonaut selects neither the trajectory of the rocket nor the orbit of the spacecraft. Scientists and specialists here on Earth, with the help of computers, calculate them in accord with the flight program.

The exact moment of the launch is decided in advance, and the spacecraft's acceleration is calculated in advance (for insertion into orbit, an Earth satellite has to reach about 8 km/sec). The angle of the orbit's inclination in relation to the Earth's equator, the apogee and perigee of the orbit, the time of one revolution around Earth, and the time and location of landing are all predetermined. After the launch, once the Earth satellite is in orbit, specialists measure all orbital parameters and determine whether there are any deviations from what had been calculated. Usually, these deviations are very minor. The TASS communique speaks of the fact that the spacecraft's orbit is close to that which had been planned and that, for example, it is made up of the following: the period -- 88.57 min, the apogee -- 215 km, the perigee -- 200 km, the inclination 51.7°. /30

However, this does not mean that the cosmonaut has no role in controlling the movements of his spacecraft.

When he takes the control of the spacecraft into his own hands, the cosmonaut can change its position in orbit: he can turn it so that it flies with its bow forward or, on the other hand, with its stern forward. He can make it turn about its vertical axis (rotation), stabilize its flight, i.e., stop the rotation and makes the spacecraft fly with one of its windows always toward the Earth and with the other toward the Sun or Moon, etc.

Finally, by using manual control and by firing this or that engine, the cosmonaut can put the spacecraft in a higher or lower orbit; he can make it extended and elliptical, or he can approximate a circular orbit.

If two spacecraft are in orbit, or if a spacecraft and a space station are in orbit, the cosmonaut can rendezvous, moor,

and dock with the other spacecraft or space station; then he can undock, move apart, and continue his flight in his own orbit.

In short, modern spacecraft can perform complicated maneuvers in space, and cosmonauts must know how to control them.

To control means to orient the spacecraft in space, to determine its orbital position in relation to reference points (the Earth, Moon, planets, stars), and then mark out a further course of choosing the necessary maneuver, which the spacecraft must perform, and by firing this or that engine assure that the spacecraft moves along the course or performs the maneuver as planned.

The Soyuz spacecraft has various propulsion systems; it is equipped with modern navigational devices; and it is provided with automatic and manual control systems.

The cosmonaut must also learn how to use all these systems, to operate the manual control system accurately, to know the principles and the logic of the operation of the automatic control system. /31

To solve all these navigational problems successfully, we carefully studied the fundamentals of space navigation, space astronomy, and the autonomous navigation equipment of our Soyuz-9.

In special training sessions on airborne laboratories and specialized simulators, we refined methods of autonomous navigation and orientation, as well as methods for using the spacecraft's navigation systems while in space flight.

As a result of our training, we learned how to select those navigation systems which would assure the most precise definition of the elements of the spacecraft's orbit; to make navigational measurements using manual means of navigation and orientation; to solve navigation and ballistics problems; to analyze one's navigational position in flight situations unforeseen by the flight program and to choose the means and methods of solving problems as they are conditioned by given situations.

* * *

Because photographers and movie cameramen have still not been sent into space, all this work falls on a small crew, who have to take pictures through a window -- pictures of the Earth's surface, cloud cover, various space landscapes, and the spacecraft's interior -- record on film the results of experiments, take pictures of the crew's work during the actual flight. It is not so much for the sake of demonstration as it is for science: to scientists, such film is a record which preserves the results of experiments and the work of the crew during the mission. While the cosmonauts are undergoing film training, the details of

operating the camera and taking photographs in zero gravity are taken into account, as are the various lighting conditions on the Earth's surface and in the spacraft cabin, the cramped cabin conditions, the time limitations (in photographing the area being flown over), and the limited supply of movie and still film on board.

While training, we were familiarized with the fundamentals of optical and photographic theory. We studied the rules for handling and operating the cameras on board Soyuz-9. /32

Naturally we did not limit our photographic training to only those activities provided for in the program.

Many cosmonauts acquired a great deal of movie and photographic equipment and used every available opportunity to take pictures. We now could not do without movie and still cameras. At home we started photo albums, got projectors, and showed our favorite films.

I should add that many of us became geniuine photo and movie cameramen, achieving filming quality prossibly rivalling that of some professional photographers.

* * *

Everything we received during our special theoretical and practical activities we later refined on special simulators, on training spacecraft, with whose help the conditions of space flight were simulated.

On specialized simulators, we refined our skills in controlling the spacecraft while performing separate and highly complex operations (stages) of the mission; these operations required many repetitions before they were mastered. Among these operations were spacecraft orientation -- through the use of various instruments -- making orbital corrections, astronavigational changes, and the like.

Each operation was repeated tens and perhaps hundreds of times during the training period.

"Why so many?" the reader asks. So that in space, during the actual mission, each operation can be carried out automatically, easily, and freely.

I can show what such training achieves with a simple example, which you can check in practice. You of course watch with pleasure as our famous figure skaters perform on television. The coordinated and amazingly synchronized skating of our pairs and dance pairs has undoubtedly delighted you. The ease with

which athletes perform intricate elements has struck you. It begins to seem as if I too can do this, not so beautifully perhaps, /33
but surely any part of it.

And then you try it. You put on the skates, go out onto the ice, and for a start you do, say, a jump with one and a half turn or a pirouette. But unless you have practiced it a long while, you can't do it. But after all it is only ice skating.

Working conditions in space are quite specific: zero gravity, a condition which is completely alien to man, and to which his body is not adapted. In zero gravity the usual reference points are lacking. There is neither "up" nor "down." Although we cosmonauts do not have to make acrobatic leaps and pirouettes, our every working movement nonetheless demands a particular precision, accuracy, an automatic motion. So we must do and redo all this many, many times.

But I have digressed; let us return to our simulators. We have spoken about the special simulators which train single elements. On a more complex trainer, however, we run through the entire flight program. This complex trainer is therefore the analog of a spacecraft.

On one of these trainers, the entire set of the flight objectives is determined. It is a study and practice ships. Its interior and equipment and the crew's activities in controlling the ship are very close and realistic simulations of conditions in space.

The peculiar feature of training on a complex trainer is the multitude of tasks which the crew, all working at the same time with a whole complex of systems, must perform. Therefore, before beginning training on the complex trainer, the crew members complete their engineering and technical preparation on all systems and in all the experiments to be done during the mission.

The crew trains on specialized and complex trainers in order to acquire and refine skills in controlling the object and its systems in normal and contingency (anticipated and unanticipated by the flight program) situations during different parts of the mission; to develop skills and techniques for working with the scientific and photographic equipment; and to establish an operation sequence for doing the complex of scientific experiments and tests envisaged in the mission's research program. /34

During training we strengthened and deepened the knowledge we received from our engineering and technical instruction; we honed our skills in controlling the object and its systems during various segments of the flight; and refined our techniques of manual orientation and orbital correction using instruments and

indicators, our monitoring of the status of the operations of all systems in the complex, and the discovery and removal of possible malfunctions.

We developed our techniques and skills in controlling the operation of the systems during prelaunch preparation (the checking of equipment and the work capacity of systems) and during the automatic modes of the mission. We refined the crew's activities when contingency situations of various kinds arise on board, when doing scientific, technical and biomedical experiments and tests, radio communication, television reports, and camera work; and during descent, landing and postflight.

In the trainer we designated the postures and methods of immobilizing ourselves by using onboard equipment -- while carrying out operations with instruments and equipment, and while doing experiments and control operations. We worked on maintaining the real-time operation sequence of the flight program; we sharpened the interaction between crew members and ground control groups; and we also worked on onboard documentation, its content, its extent, its components, and we tried to gain skills in working with it while carrying out the concrete operations of the mission program.

We acquired skills in evaluating qualitatively the design and use characteristics of the simulator's special systems; and we appraised the operating convenience and layout of the equipment in the spacecraft crew quarters.

In addition, we did research in the complex trainer on allocating control functions to the crew members and the automatic systems; we evaluated the design and placement of instruments, indicators, gauges, control apparatus, the command-transmitting console, the scientific instrumentation console, and other onboard equipment. /35

The training was conducted according to a program which was developed in accord with the training program and with the aerospace research objectives of the Soyuz-9; and in accord with the functional duties the crew members were to carry out during the mission.

In developing our training program, we always adhered to the principle of consistently gaining mastery over the spacecraft from the simple to the complex; and we were careful to include a maximum number of operations dealing with activities in contingency situations.

Constructing such a training program was done so as to bring the crew's work conditions as close as possible to what they would be during actual space flight.

Special attention was given to training the crew's actions in analyzing the operation of individual assemblies and systems. All contingencies which could arise during the actual mission in space were run through on the simulators. Special attention was given to ensure that crew members knew how to discover malfunctions in time; to analyze the situation quickly; and on the basis of the information at their disposal to make a quick and expert decision on how to correct the malfunction.

Before beginning each successive training session, we always discussed and defined our tasks, and together with our instructor, we studied the theory and methods of doing the training. Then we were given the initial data on the status of the simulator's systems, and the crew's attention was directed to the fundamental problems of the work that lay ahead.

After finishing the training session, the crew members and instructor analyzed it. They analyzed how the objectives had been accomplished, they cleared up any debatable or uncomprehended questions which had arisen during the training session. In conclusion the instructor made a general summation of the work that had been done and posed the problems we would have to deal with at the next session.

During the mission, part of the experimentation and research was to be done by each crew member individually, and part was to be done jointly. The crew members' training for this experimentation and research was made up so as to accord with the tasks each /36
crew member would have to perform. That part of the research program which the cosmonaut was to do himself, he trained for individually. That part which was to be done jointly, by both crew members, we worked on at joint training sessions.

Our training for the space flight was culminated by comprehensive training on a mockup craft. During this training we were to do all parts of the fundamental stages of the flight program -- this in conjunction with the mission control working group. The results of this final comprehensive training determined whether each cosmonaut and crew member was fully prepared for the forthcoming space mission.

* * *

In space flight conditions the cosmonaut is removed from the familiar conditions of Earth. The abrupt change in his environment invariably causes emotional tension, which is itself an additional burden on the body.

The unusual and unfamiliar conditions of space flight and the effect of these conditions on the human psyche can be

substantially reduced by training the cosmonauts in conditions similar to those in space flight and also by giving them training which produces the same emotional stress. On Earth, such training can consist of airplane flights and parachute jumps.

Aviation training in the cosmonauts' general training cycle allows them to acquire needed psychological qualities, reduce emotional tension and thereby improve their preparation for the flight program to a significant degree.

During this flight training we studied and refined the techniques of testing a spacecraft and its systems, the autonomous navigation aids, and observation devices, as well as our methods for doing research and experimental work in space. We also /37
developed and improved our professional skills in controlling the spacecraft and its systems, as well as our skills in allocating our attention while monitoring the piloting-navigation, monitoring and recording instruments.

Flight training also helps develop the ability to suppress negative emotions and to make well-founded, rational decisions as quickly as possible in rapidly changing conditions. It prepares the body to work under the impact of acceleration, vibration, noise, vestibular discomfort, i.e., even when one experiences very unpleasant sensations, sensations connected with the functioning of the vestibular apparatus at zero gravity.

It helps develop the cosmonaut's will power and moral qualities, as well as his skill at solving the difficult problems which arise unexpectedly during space flight and in the education of specialists able successfully to master space technology.

Special flight training of cosmonauts, both in the USSR and USA, is considered one of the most important parts of training. The first cosmonauts were selected from among pilots; consequently, when other specialists, engineers, and doctors entered our ranks, they had to make plane flights in accord with a special flight training schedule.

The next stage is parachute jumping. It has a special place in the training of cosmonauts. As pilots we had had to make parachute jumps previously. Every pilot should know how to do it. A parachute can save the pilot's life when the plane malfunctions. However, parachute jumping has an entirely different role in the training of cosmonauts.

Parachute jumping, which includes a series of operations and assignments during free fall and after the parachute has opened, helps form the cosmonaut's pyschophysiological qualities; and it develops the skills he needs to carry out missions in space: self control, discipline, the knowledge of how to endure great

physical and emotional stress, boldness, courage, decisiveness, purposefulness, and resistance to great nervous and emotional tension in unexpected situations.

When I attended aviation school and served in air units, I had all of ten parachute jumps on my record. This was quite enough for me, a pilot, to know how to proceed when bailing out of a malfunctioning airplane. /38

Yet while I was a cosmonaut, a much shorter period of time, I made at least ten times as many parachute jumps as I had before.

As the cosmonaut completes parachute jumps, his natural feeling of danger and fear of the unknown changes into confidence in his own powers; and as he masters the technique of jumping, he becomes accustomed to unusual circumstances. The acuteness and force of his negative emotions is reduced, and he develops long-lasting skills. He becomes able to perform consciously, in a short period of time, a series of actions connected with the exertion of his intellectual, spiritual, and physical powers, and to do this in complicated conditions uncommon on Earth.

Daring and decisiveness, firmness and bravery -- all these qualities of the will are instilled by bailing out of various kinds of airplanes and helicopters and with various types of parachutes. Parachute jumping with the goal of landing on a target shapes the cosmonaut's readiness to take logical and rational actions in a complicated situation; it also instills the ability to make rapid evaluations and analyses of a situation and to respond to changes in the situation with accurate and coordinated actions; and it teaches self control, inner discipline, and resistance to great nervous-emotional stress.

Long free-falls gives the cosmonauts good spatial and temporal perceptions, a great capacity for work, and acute perception in extraordinarily rapid changes of circumstance. A person's intellectual and physical activity are revealed most fully in such unusual conditions.

Parachute jumping proceeds consistently from the simplest to the most complex as different assignments are carried out: the parachutists' identification of signals given from the ground, communications with the ground, free-fall in tandem and so on.

* * *

During space flight, the cosmonaut's body is subjected to the impact of a whole series of specific factors which he does not encounter in ordinary daily life on Earth: heavy g-loads during the spacecraft's ascent and descent; prolonged weightlessness as the spacecraft moves in orbit around the Earth; the /39

limited extent to which one can move about during a long stay in a small, closed cockpit (while at the same time zero gravity reduces the force needed to move about); and cosmic radiation, to whose effects the cosmonaut can be exposed, particularly during unexpected solar flares.

In addition, the emotional burden of being in the uncommon circumstances of space flight, of feeling responsible for the testing of irreplaceable technology, can affect the cosmonaut's psyche. Finally, a lengthy stay in a confined and relatively small cockpit can also influence the cosmonaut's psyche.

It should be said that the effect of these and other uniquely space factors, not enumerated here, is quite substantial.

Let us take only g-loads.

Even a relatively small g-load has a rather strong impact on an untrained and unprepared man, for he cannot actively perform intricate actions and has difficulty in making observations: his eyesight worsens, his heart rate quickens, and sometimes the so-called "extra systole" can occur (unsynchronized contraction of the heart). In heavy g-loads, a man can lose consciousness.

And as for weightlessness? One experiences something like weightlessness when a ship at sea pitches strongly or when an airplane hits a so-called "air pocket." When a ship or a plane "fails" in this way, a very brief period of weightlessness ensues. One who is unprepared for it experiences a sensation of falling, he loses his orientation in space, and if his vestibular apparatus /40 is weak, his head begins to spin. An illusory sensation sets in: it is as if the walls, the ceiling, the whole world were falling in on him. Unpleasant sensations also appear in the stomach -- this conditions is usually called discomfort; nausea and vomiting can follow.

The enforced limitation of movement in the small cabin of a spacecraft can also affect on adversely.

Remember how you stand up alone for the first time after a serious illness forces you to stay in bed many days -- your muscles are weak, your head whirls, your walk is unsteady, and each movement is made with difficulty.

But in a spacecraft at zero gravity, even if a cosmonaut makes certain movements, they put no burden on the muscles: the human body and all that surrounds it -- instruments, machines -- weigh nothing!

This is why serious attention is given to the biomedical and physical training of cosmonauts for space flight. It is no

accident that special medical commissions find from among a great many aspiring cosmonauts those who are healthiest and physically strongest in all respects, those who already possess the special qualities a cosmonaut needs, those who will rise still higher with training.

All those who join the ranks of the cosmonauts study the theoretical disciplines which relate to the fundamental questions of aviation and space medicine. But theory is blended with practice at all times. For example, after hearing a course of lectures on the effect of g-loads on the human body, we pass through tests on a centrifuge, where we can check on ourselves whether the theoretical propositions we were given are correct.

After hearing lectures on life support systems in space flight, we became acquainted during our practical training with all these systems, learned how to control them, and how to repair any defects that arise.

Since every space flight is not only a test, but also research, we studied both the theory and the practice of doing various biomedical tests and experiments. But I shall tell about this in more detail later. Now I wish to dwell for a moment on all the training we had to pass through before our launch into space. /41

* * *

Exceptional attention has been given in recent years to the problem of maintaining normal vital activity and work capacity in zero gravity. The first missions showed that the cosmonauts' health in zero gravity was good and that on the whole man adapts rather quickly to life and work in these unusual conditions. While I was making my first flight, or 4 days, I did not notice any serious abnormalities in how I felt or how much work I was able to do.

My comrade on my first mission, Pavel Popovich, the commander of Vostok-4, described how he felt during the mission and wrote the following in his logbook: "During the 3-day flight, all forms of work were done easily, without exertion and without fatigue. My capacity for work remained high throughout the mission. It was easy to work, I felt fine, and my mood was cheerful." Our other cosmonauts and the American astronauts on the Gemini and Apollo missions evaluated how they felt in about the same way.

However, despite this general sense of good health, several physical abnormalities were nevertheless observed during these missions.

They appeared as excessive alertness among some cosmonauts. Other cosmonauts experimened lowered, and still other heightened, motor and speech activity. In some, illusory sensations about the body's position in the spacecraft's cabin appeared (especially when the eyes were closed or when they were not firmly strapped into their seats), in others there was gastrointestinal discomfort, and in yet others the blood flowed to the head, the face puffed up, etc.

Gradually all these sensations and phenomena weakened. However, during a longer period of weightlessness slightly different phenomena also begain gradually to appear: skeletal muscle tone was lowered, there was a rather marked demineralization of the bony tissues, and the body became dehydrated. /42

The present stage of progress in space flights is characterized by the exceptionally important role given to the man during the mission. During a prolonged mission, the cosmonauts have to carry out a great deal of crucial analytic and physical work in zero gravity: many very different scientific experiments; rendezvous, approachs, docking and undocking of spacecraft; and transfer from one spacecraft to another. The successful execution of the flight programs is linked in this way not only with the healthy and well-being of the cosmonauts, but with also a highly efficient work capacity on their part. In this regard, special attention is given to training the cosmonauts to work in zero gravity.

In our theoretical exercises, we became acquainted with the available literature on the influence of weightlessness on the human body. The phsyiological mechanism by which weightlessness affects man was explained; the way to prepare the body for the impact of weightlessness was set out; and the necessary recommendations were given.

An important place in the cosmonauts' training program was devoted to vestibular training.

Vestibular accommodation varies among people. Those with an unstable vestibular apparatus experience illness, vertigo, and occasional nausea (discomfort) when it is stimulated over an extended period of time. These can be accompanied by paleness of the face, copious perspiration, and sometimes vomiting. Therefore, medical specialists, when they select candidates for cosmonauts, pay particularly close attention to the adaptability of the vestibular apparatus.

The main role in raising the accommodation of the vestibular apparatus is given over to vestibular training.

Special training on Earth promotes the ability better to withstand vestibular irritation and to adapt better to weightlessness during space flight.

That the vestibular apparatus may be conditioned is well known. But increasing its accommodation does not proceed at the same rate in different people. Therefore, the length of each cosmonaut's training cycle is determined individually. During /43
training, the effect on the vestibular apparatus is gradually increased, either by longer training sessions or by increasing the stimulus.

In training for a long mission, increasing vestibular accommodation is done by using both active and passive methods.

Before beginning the training cycle, tests on the functional condition of the vestibular apparatus are made. These results, as well as those of tests made after the training session, allow us to establish which stimuli cause the most pronounced physiological reactions. As a result, a training cycle is devised with these features in mind.

Active vestibular training includes work on gymnastics equipment ("looping rig," trampoline, and vertical body wheel) and the performance of special acrobatic and free exercises. These exercises consist of those element which affect the vestibular apparatus -- somersaults, head bends, and trunk bends in various directions, simple jumps and jumps with turns of 90, 180 and 360 degree, and also exercises which have to do with the rotation of the body in different planes.

Passive vestibular training did not require active muscular exertion and was done on special devices and stands which create various kinds and magnitudes of accelerations; these in turn stimulate the vestibular apparatus.

Here are some of these devices.

The general-purpose swivel chair is designed to develop i. vestibular accommodation to the effect of angular and Coriolis acceleration. This chair is set on a platform and can rotate with various kinds of angular acceleration. As the chair spins, the cosmonaut sitting in it has to do various exercises, such as head bends or trunk bends, at a predetermined pace. At the beginning of training, he can have the illusory sensations that the chair is rolling or inclining forward or backward, depending on the direction the chair is spinning and the head is moving.

At first, prolonged rotation may cause nausea even in people /44
with good vestibular accommodation. The task of the physicians

who observe them is not to allow this to happen and, using systematic training, develop a good accommodation in the cosmonauts' vestibular apparatus to angular and Coriolis acceleration.

A swivel chair whose base becomes unstable is a chair placed on legs and air balloons. At first the chair is firmly fastened down. When the legs are taken away, the chair is supported only by air balloons and thus is located on an unstable base.

The cosmonaut in training assumes a designated position in the chair and inclines his head this or that way (determined in advance). After spinning at a constant speed, the chair stops and is at once transferred to the unstable support. The cosmonaut's task is quickly to put his head in a vertical position and in this way not upset the equilibrium of the chair. At first this was rather difficult to do; it seemed throughout that the chair was inclining to one side or the other. You begin to restore your equilibrium, and you make your position even worse.

After a cycle of training sessions, we were able to avoid losing our equilibrium on the unstable chair. Consequently, it can be concluded that our vestibular accommodation to the effect of angular acceleration was increased.

The Khilov swing is a four-pole swing. A chair is placed on its platform, and a cosmonaut in the chair. The feature of this swing is that the platform on which the chair is placed moves continuously forward and backward parallel to the ground; in this way the person in the swing does not change his position relative to the vertical as he does on ordinary swings.

While the cosmonaut swings on the Khilov swing, tests are done on, and training is accomplished of, his vestibular accommodation to straight-line acceleration, which basically affects the otolith structure of the inner ear.

The optokinetic drum is a large cylinder placed in a vertical /45
position. Its inside wall is painted with alternating black and white stripes, which are placed at a designated angle to the horizontal. A chair on an unstable basis is placed inside the drum. The drum rotates clockwise or counterclockwise. As it rotates, the cosmonaut sitting in the chair remains motionless. He looks at the stripes flashing by in front of him and tries to maintain his equilibrium. An untrained person can have the illusion during all of this that the drum is not moving and that he and the chair are rotating in a direction opposite to that of the drum. Sometimes he can feel an apparent inclination of his chair, or he can simply lose his spatial orientation. The illusory sensation of rotation that appears can be accompanied by a loss of equilibrium. Then the trainee begins actively to "correct" his position. The losses of equilibrium and the attempts to regain it

are often accompanied by deep inclinations of the chair, and it then becomes impossible to restore the chair to its original position. In addition, those who do not have a sufficiently high accommodation to optokinetic effects can experience discomfort and other symptoms, whose character is reminiscent of the condition of motion sickness.

As the training cycle proceeded, our illusory sensations weakened or disappeared completely, and the vegetative reactions (pulse rate, respiration rate, blood pressure) returned to normal during these optokinetic stimuli. If there were unpleasant sensations at the beginning of training, then they had fully disappeared by the end of the training cycle.

* * *

Vestibular training of crew members on Earth significantly increased their vestibular accommodation to the effects of space flight factors, contributed to high work capacity during the mission, and thus to complete and efficient performance of flight objectives.

After a series of training sessions for the vestibular apparatus, we passed on to more complicated training -- on airborne laboratories.

While on these airbonre laboratories, we became acquainted /46
in practice with a number of unusual sensations caused by weightlessness. We did a series of operations which we were later to encounter in actual space flight. Weightlessness in these airborne laboratories, to be sure, lasts 20-25 sec.

Flying an airplane along a parabolic trajectory produces weightlessness. At the end of this trajectory, when the plane resumes level flight, weightlessness disappears. Then the pilot once again gains height and velocity, so that a brief period of weightlessness is again produced. Thus, in a single flight, weightlessness is produced many times.

During these periods of weightlessness, medical specialists made careful observations of our actions and recorded our physiological indices -- electrocardiograms, encephalograms, pulse rate, respiration rate, blood pressure -- on the basis of which conclusions were drawn about the character of our reactions as we did certain operations during weightlessness.

Our training program in conditions of weightlessness depended on the basic objectives of our upcoming space mission. Thus, Pavel Popovich and I, as well as our backups, practiced leaving our seats and free floating about the cockpit even before we made our first mission. The Vostok-2 crew, Pavel Belyayev and

Aleksey Leonov, practiced even more complicated elements on these airbonre laboratories: donning and undonning their space suits, airlock pressurizing and depressurizing, making exits from the spacecraft, moving away from it, moving toward it, and reentry into the spacecraft. Later, the Soyuz-4 and Soyuz-5 crews (V.A. Shatalov and B.V. Volynov, A.S. Yeliseyev, Ye.V. Khrunov) practiced all the actions connected with transfer of the cosmonauts from one spacecraft to another.

In airborne laboratories were thus polished primarily the cosmonauts' skills in moving about as they did scientific experiments, performed personal hygiene, ate, etc. How much training the crew members received in short-term weightlessness depended on what their duties were to be on their mission. /47 During these training sessions, the time an individual required to perform a flight assignment was calculated, as well as the time needed to correct practically the cyclograms of actual space flight and the character of psychophysiological reactions of the cosmonauts as they did their assigned exercises. This allowed us to determine how much work was needed to perform operations in conditions of weightlessness.

At a press conference in March 1965, Aleksey Leonov evaluated this weightlessness training: "Training in conditions of weightlessness on airborne laboratories made it possible to a certain degree to get the feel of space while still on Earth and to develop firm practical skills. It is not surprising that while making an actual space flight and while spacewalking, we essentially did what we had already done several times in training." Yevgeniy Khrunov also gave a similar evaluation of this weightlessness training: "The level of training was sufficient. In the airborne laboratories we refined all operations to the extent that as we donned our space suits and prepared to go through airlock procedures, we sometimes forgot that we were not on an airplane but on an actual space flight, and we did everything as if on regular training sessions."

While in training for the Soyuz-9 mission, Vitaliy Sevast'yanov and I also made may flights in these flying laboratories. During brief periods of weightlessness, we developed our skills in doing individual daily occupation and working operations. This training helped us successfully carry out the program of our long mission into space.

* * *

I have already written that in the original selection of candidates for cosmonauts, the scientists gave preference to figher pilots. Why they did this is clear, it seems. Pilots are the healthiest, the best-trained physically. They are familiar with the sensation of flying, they are used to g-loads, and they

know what weightlessness is, even if only briefly. As a rule, /48
pilots are well-prepared in terms of general education, and they are familiar with technology in general. Nor do they lack daring and courage.

But passing through all the obstacles to selection and being counted a cosmonaut does not make a pilot a cosmonaut all at once. More, much more, work has to be accomplished.

The g-loads during ascent and descent last longer than in an airplane, and only a person who is very well-conditioned physically can endure them. The same is even more true of going out of the cabin into space itself, where not only physical strength but also endurance, excellent physical coordination, and great self-control are necessary.

Physical culture and sports are a fundamental part of a cosmonaut's training for a mission in space.

Physical training may be divided for the sake of convenient into two separate parts. The first is the development of physical qualities, such as strength, endurance, dexterity, quickness. The second is specialized physical training, whose goal is to increase the body's accommodation to the hazards of space flight: g-loads, weightlessness, and prolonged hypokinesis (where there is little movement of the body, and where these movements require little exertion).

Physical training is not limited only to offical activities.

The work day of a cosmonaut always begins with a good morning exercise session, which is no less than 30 min. In addition to general exercises, these exercise sessions must include exercises to condition to vestibular apparatus and exercises to develop certain muscle groups.

The study and training sessions of the cosmonauts are done 2-3 times per week -- 2 hours each -- depending on what training period they are then in. All-around physical training is the main feature of these activities. The cosmonauts have to train in nearly all kinds of sports, for each sport develops in some measure certain qualities needed on a future mission. Gymnastics and acrobatics improve the compensatory reactions of the vascular system. Skiing and cross-country running develop endurance. Long periods of swimming contribute to skills in consuming oxygen correctly. Diving into the water from a height develops coordination of move- /49
ments and a knowledge of how the control one's body while in the air.

But athletic games are also a part of the physical training program at all stages. This is understandable. Quickness,

prudence, reaction to unforeseen situations, concentration, collective action -- all these are best developed in athletic games. These sports also do a great deal to determine "psychological compatibility." This is why in our tennis matches, the doubles pairs are made up of those cosmonauts who are training for a space flight in the same crew. This helps them better know each other, to feel one's comrade at one's elbow in a difficult situation.

After attaining a high degree of general physical fitness, the cosmonauts spend a great deal of time developing special attributes useful in the upcoming mission. Workouts on the looping rig, the trampoline, the gymnastics wheel, the vertical swing, and other pieces of equipment have a special place in this respect.

Spinning on the looping ring at 40 rpm creates g-loads of 8.5 at the feet and 5.4 at the heart. These exercises are excellent for g-load training.

The strain on the cardiovascular system while working out on the looping rig is quite high. The heart rate reaches 160-180 beats per minute even among those who are in good physical shape.

One of the cosmonauts' favorite pieces of equipment is the trampoline. I would not be mistaken if I said that many of us could successfully compete on this piece of equipment. Working out on the trampoline increases the functional capabilities of the cardiovascular system, they condition the vestibular apparatus, they develop the ability to control one's body in space, and they improve coordination. Workouts on the trampoline begin when the cosmonaut begins training for his missions, and they continue uninterruptedly.

The vertical swing is also used to good advantage. This piece of equipment consists of two parallel springs attached to the walls. The trainee fastened himself into a suspension system. He pushes away from the floor, leaps high, and turns forward and backward somersaults. The jumps may reach 4-5 m high. These /50
workouts develop one's sense of orientation in space and the ability to coordinate movements while in the air.

In addition to developing one's physical abilities and increasing the body's accommodation to the elements of space flight, sports are an excellent way to instill moral qualities. Many people begin to cultivate physical culture and sports. But do they all have enough will power to do their morning exercises regularly? Is it really easy to run 5-7 km cross country, to swim 1.5-2 km, and then to work out on special training equipment -- as do the cosmonauts? Behind all this is hard work and great

will power. In order to force oneself to do all this exertion, one must be physically and morally prepared for it.

Sports helps us overcome any difficulties. It is genuinely helpful in any profession. It is indispensable to a cosmonaut.

Yuriy Alekseyevich said: "What is demanded of a cosmonaut? In addition to will power and firmness, he needs great endurance, hardiness, and physical strength. These come from being in good condition. Infatuation with records is not necessary, all-around sports activities are."

All-around sports activities. Beginning with Yuriy Alekseyevich Gagarin, who was the first to open up space, all the cosmonauts, without a single exception, spared neither time nor effort for these activities.

Yuriy Gagarin, while still in trade school, loved basketball. After graduation he even intended to study in the Leningrad School for Physical Culture. While working as a foundry worker and molder, Yuriy spent all his free time at sports. He played basketball, volleyball, he skiied, he worked out at track and field, and he played hockey and tennis.

In his book Dogora v kosmos [Road to the Cosmos], he wrote: "Systematic sports activity contributed to my growth as a pilot and air ace." After his space flight, and despite his heavy workload, he tried to save some time to play basketball and volleyball for his team at the command. Yuriy Gagarin was our first community coach in water skiing. He considered water /51
skiing an excellent way to develop muscles and teach character and will power.

Gherman Titov began his athletic carrer with a liking for gymnastics and acrobatics. In these, he has achieved the second class sports ranking. Among the cosmonauts he is an avid hockey player. Even now he plays boldly and vigorously, and he is not afraid to use forceful methods when fighting for the puck. In tennis, he is known for his strong attacking strokes.

As for Pavel Popovich, who knows, if it had not been for his attachment to aviation, we perhaps would have seen him on the dais of world champions in the field events. He had not abandoned this pursuit even now. He also makes appearances for the cosmonauts in swimming, skiing, and basketball competition. Furthermore, he directs the mass sport operations among the cosmonaut-aviators.

Valeriy Bykovskiy has had a predilection for sports since childhood. He has good reactions, and the cosmonauts often entrust him with the position of goalkeeper when playing soccer. In hockey, Valeriy usually plays as an attacker. He is also an

excellent short-distance swimmer. But if he has no equals, it is in skittles.

Not everyone knows that parachuting, the sport of the brave and the daring, helped Valentina Tereshkova get into her work in space. She has almost 200 jumps to her credit. She loves swimming, water skiing, and badminton. But her favorite piece of equipment is the trampoline; she was working out on it even when it was considered a man's sport.

Vladimir Komarov had serious surgery while already a cosmonaut. Many thought that after this, specialized training was beyond Vladimir's capacity. But his excellent physical conditioning and the hardiness he received from sports helped him overcome this obstacle. He loved cross-country skiing, swimming, and other athletic games. We give a special sports award in his memory.

Konstantin Petrovich Feoktistov is also a good athlete. He plays an excellent game of tennis and ping-pong. He loves cross-country running. His bearing is upright, and he looks like an athlete.

Boris Yegorov is interesting in the more dangerous sports. /52
As a youth, he loved alpine skiing and mountain climbing. He has completed about 20 ascents of the snowy summits of the Caucasus. As with everything else, this was of advantage to him during his three-man mission on the Voskhod! Boris has other enthusiasms in sports: tennis, swimming, skin diving, and cross-country running. He has ranking badges in all different kinds of sports.

The oldest of the first, "Gagarin" group of cosmonauts was Pavel Ivanovich Belyayev. He is a strong-willed man who knows how to restrain his emotions. Perhaps he got these qualities while still a child, when he went hunting with his father, hunting even for bears. He also loved skiing. When he became a naval pilot, he thought that swimming was something he should master. He liked long-distance foot races best of all. Not long before his space flight, as he was making training parachute jumps, he broke his leg while landing in windy weather. Thanks only to his strong will power and his good physical condition was he able to recover in a short period of time and make the spaceflight successfully.

Aleksey Leonov even now speaks with great respect for bicyclists. As a yout he himself took part in bicycle races and knows how difficult it is to force oneself to be the leader of a group of bicyclists, when sweat clouds the eyes and the muscles are driving under great strain. Aleksey likes throwing the javelin and bests his rivals in many competitions. The cosmonauts consider him one of the best at spiking the volleyball; he jumps very well and spikes strongly. He likes cross-country running

very much. He says that it is everything: training of the will as well as of the body. Many athletes could well envy his physical development and his body build. Aleksey Leonov is, incidentally, head of the All-Union Council on the GTO [Ready for Labor and Defense of the USSR] Physical Culture Organization.

Before Georgiy Timofeyevich Beregovoy became a cosmonaut, he was a test pilot. This profession, as well as that of a cosmonaut, demands perfect reactions, strength, endurance, and coordination. Regular sports activities helped Georgiy Timofeyevich maintain his fighting form. There was one such case /53
during his space flight training. While he was working out on the looping rig, a reinforcing chain broke. Thanks only to his great self-control and his "athletic analysis" of the situation was he able to slow his velocity and avoid an unpleasant accident. Georgiy Timofeyevich likes water skiing, swimming, and diving very much. Among other things, I note that Georgiy Timofeyevich learned how to swim only when he was already a cosmonaut, at the age of 42. He had to, he forced himself to, and he learned how.

Vladimir Shalatov, although over 40, has the build and bearing of a youth. Nor does he reduce the demands he makes on himself even, as they say, a single iota. Every morning the residents of Star City see him on the cross-country paths. Few venture to compete with him in the breaststroke. He likes skiing very much, but skin diving most of all. Vladimir Aleksandrovich thinks that skin diving is extremely helpful in training for space flight.

Boris Volynov is a ranking competitor in sambo. In turning backward somersaults on the trampoline, he reaches such a height that it seems his body will disappear into the air. He also likes tennis, hockey, and basketball.

Sports has a prominent place in the life of Aleksey Yeliseyev. Aleksey is a master of sport of the USSR in fencing. The years spent on the fencing strip have developed his endurance, quick reactions, prudence, and a number of qualities which were of help on his space missions.

Yevgeniy Khrunov's favorite sport is diving. He practiced at it until his instructor gave him marks of "excellent." He like tennis very much. He reaffirms his second-class sport ranking every year in the ski competitions.

Georgiy Shonin grew up near the sea. As a youth, he competed in swimming and diving. Long-distance running is still one of his favorate sports, yes, and not only running. He is our best defenseman in soccer and is a good spiker in volleyball. In hockey and basketball, all the plays center mostly around him.

Valeriy Kubasov is a good gymnast; this he did while still a schooboy. He has one other enthusiasm -- skiing. He regularly takes part in skiing competitions. /54

Anatoliy Filipchenko surprises his comrades with his strength and coordination. His handstands on the parallel bars are strikingly elegant. While learning a complicated move on the trampoline, he needs no more than a single session. He can easily do a series of 25-30 backwards somersaults on the trampoline.

When Vladislav Volkov came to the cosmonauts' training center, we saw a classic athlete. He had taken part in sports as long as he could remember. He excelled particularly at athletic games. He is a soccer and hockey player of first ranking. Thanks to his perseverance and industriousness, he got high marks in every sport. On April 12, 1971, the "Day of the Cosmonauts," the space center held tennis competitions. Together with his partner, Vladislav won first place and received a certificate.

Viktor Gorbatko's favorite sport is tennis. He is tennis champion among the cosmonauts. He is very persistent, or, as tennis players say, he "reaches" to return all balls. Viktor is also a ranking skiier.

I have already mentioned Vitaliy Sevast'yanov. I will add only that he is also an all-around athlete. He loves to play tennis and volleyball, and to swim and ski.

Nikolay Rukavishnikov is an ardent fan of motorcycling and tourism. I remember how, when he came to the cosmonauts' training center, he lobbied persistently to have these sports included in our physical training program. He also likes bicycling, swimming, cross-country and skiing.

The trampoline and diving are Georgiy Dobrovol'skiy's favorite sports. I remember the industry which which he did his training exercises. Few cosmonauts equalled him in these sports. Not long before his space mission, he was training to meet the norms for a first ranking in the trampoline. He said, " I will be flying, I will have to meet them." There was no greater soccer enthusiast than he. He spearheaded the attacks. He scored goals often and beautifully.

Viktor Patsayev gave a great deal of attention to working out on special training equipment. Here his mentor and teacher was commander Georgiy Dobrovol'skiy. In soccer, they played beside each other. But most of all he loved skin diving and spear fishing. He spent many winter evenings improving his underwater equipment. When summer came, he tested it under water. /55

Vasiliy Lazarev, Oleg Makarov, Petr Klimuk, and Valentiy Lebedev are good all-around athletes.

I have named all those cosmonauts who have already made space flights. I can attest that those who are still training to make flights, those such as the pilots Volodya Dzhanibekov and Yura Romanenko and the engineers Boris Andreyev and Sasha Ivanchenkov, as well as all the rest of the boys, are all great lovers of sports. Many have ranking badges. Some even have two or three. Almost all have successfully met the norms of the GTO [Ready for Labor and Defense of the USSR] organization.

* * *

These in general outline are the foundations of the cosmonauts' training.

"The supply of strength" Vitaliy Sevast'yanov and I received through systematic activities on Earth helped us overcome the difficulties of training for an 18-day mission in conditions of weightlessness and hypodynamia. Our active training of the vestibular apparatus on the looping rig, the trampoline, the gymnastics rings, the vertical swing, and other special equipment contributed to this; acrobatics, athletic games, gymnastics, swimming, skiing, running and other sports also contributed.

While Sevast'yanov and I were training for this extended mission, no little attention was given to a new problem -- that of readaptation, i.e., readjustment to conditions on Earth after completing a long mission in space. A special set of physical exercises was developed; a special "exercise-tension" suit was created; elastic cords and other devices were readied.

On Earth a food ration was worked out -- it included hot food, so as to assure a high work capacity in space. Questions of hygiene during extended space flight, as well as many other questions, were considered.

Finally, it all came to an end. The comprehensive training /56
on the mockup craft was finished. We passed state examinations on our knowledge of space technology (the spacecraft, its onboard systems and equipment), controlling and maneuvering the spacecraft while in space, scientific, technological, and biomedical experimentation, and the flight program as a whole. We passed a careful clinical-physiological medical examination. Because the results of our training and our health were good, we received the "go ahead" to carry out the Soyuz-9 space mission.

As was traditional, the cosmonauts gathered to celebrate. We -- the candidates for this next mission -- told our comrades of the work we had done during the training program and reported

that our health was good. We assured them that we were ready for the mission and that we would carry out our assignments with honor. Our comrades once again shared their own experiences with us and gave us their good advice "for the road." They wished us a successful execution of the flight program. Then Vitaliy and I, as well as our backups, visited Yuriy Gagarin's study in Star City and left "our mark" in the book of inscriptions -- a solemn promise to the Earth's first cosmonaut that we would be faithful to his memory and continue what he had begun, the pioneering of space.

On the eve of our departure, we went to Red Square to visit Lenin's tomb and the office where he had worked. We swore to Vladimir Il'ich, the Communist Party, and the Soviet people that we would do everything to prove worthy of our party and the Soviet people.

We returned to Star City and began to get ready, as they say, for the long road. We packed our suitcases slowly, so as to forget nothing. The whole family took part in getting everything together. Valentina and I neatly packed all that was needed, and Alena helped us busily. When everything was packed, she brought here little doll. Turning to me, she said, "Papa, take this doll with you, so that you won't be bored during your mission." This was very touching. I told here that the doll would always be with me, and that if I am bored, I would play with the doll and tell here all about my Alenka and her mama Valya.

To get a bit ahead, I must say that I took the doll with me /57
as a souvenir, not only to the space center, but also on my mission into space.

* * *

On the launch pad, the time came to prepare the spacecraft and launch vehicle for the upcoming mission. The days left before the launch were marked by a particularly intense tempo of work. Everyone was intense and worked with a heightened feeling of responsibility.

The last checks and tests of the spacecraft's and launch vehicle's systems and equipment occur; then the spacecraft's tanks are filled with propellant; the heat regulation system is filled with a special fluid; the crew's "provisions" are packed on board; special containers are filled with water and fruit juice; and the scientific and technological equipment for experimental and research work is put on board. Finally, the spacecraft is joined to the launch vehicle. This work proceeds strictly according to the prelaunch schedule of the whole complex.

We all took an active part in prelaunch preparation. We had to narrow down the flight program and the experimental and research operations, as well as take part in checking the spacecraft's systems and equipment.

Vitaliy Sevast'yanov and I, along with the specialists, made an onboard and thorough check of S-band and VHF communications and the broadcast radio. Finally, we fitted the communication sets and the seat belt system onto the working seats. We checked the onboard equipment designed for the scientific, technological, and biomedical research and experimentation; and we stowed the onboard documentation, the food rations, and personal hygiene aids. We inspected whether the physical exercise apparatus was in order. We packed away the pouches containing the scientific instruments, and we examined to see whether the emergency equipment supplies were in place. We measured and fitted the medical harnesses with their sensors for registering the body's physical functions. We consulted with leading development specialists and methods instructors on various technical problems. We defined more precisely the necessary questions with regard to the performance of several experimental and research operations and to the entire flight program. /58

The Soyuz-9 crew's prelaunch preparation differed somewhat from that given previous crews in spacecraft of this series; the reason for this feature was that this mission was longer than previous missions. Great attention was given to the quicker adaptation of the crew members' bodies to the conditions of the flight and operations in space.

For a number of reasons determined by the dynamics of this mission, our spacecraft was to have a so-called "progressive mode" of work and rest: at night (Moscow time), when we were flying over our country, our work was to be intense; during the day, when the orbits did not pass over Soviet territory, we were to sleep. Because of the fact that the orbits progressed during the mission, this mode would also progress, and, toward the end of the mission, it would become more normal. The plane was to land the spacecraft during the day.

So as to weaken any possible unfavorable effects on the body as a result of this important rearrangement of the customary Earth schedule, this rearrangement was done while we were still earthbound.

This preflight regimen was planned so that we gradually got used to a regimen close to that of the mission itself: we worked hard at night and rested during the day.

At the space center, our workday began with physical exercise. The specialists developed a whole system of physical

training for us to use on board the spacecraft; it was designed to do away with the effect of hypodynamia and hypokinesia, and we used it on Earth during the entire time remaining before the flight.

As we went through our activities, we gave special attention to doing correctly those exercises with a special purpose, and we also included athletic games: tennis, basketball, volleyball, table tennis, and others.

Because of the peculiar features of the forthcoming mission, our vestibular training and special training of the body to withstand the effects of prolonged weightlessness were continued during the prelaunch period. /59

Medical specialists analyzed the results of previous space missions and the reactions of cosmonauts; their analysis showed that during the first period of weightlessness a redistribution of blood occurs, which is felt as a rush of blood to the head. In our training for the mission, therefore, and in order to condition the vascular tone of the head, we were told to sleep on beds whose foot was elevated, or, more simply, we slept with our legs slightly higher than our heads.

It was assumed that physiological reactions similar to those which arise under the effect of weightlessness would be observed and that this would stimulate the same adaptive regulatory mechanisms. In our own, subjective opinions, such conditioning really helped the body to adapt more quickly to zero gravity.

Sometimes, to get rid of excess tension and have an emotional rest, we were given days off. One day we spent fishing. We drove a bus to our hotel, gave everyone fishing tackle, and said, "Let's go!" A jolly company gathered -- Vitaliy Ivanovich, our backups, doctors, engineers.

Until we reached our destination, we sang and played jokes on each other all the time. But here we are. Everyone went off somewhere, each seeking a comfortable spot. For some reason, the pike were biting on both live and artificial bait this day. I was lucky enough to catch five pike. They were all pretty big -- from 35 to 40 cm. As I took my last pike off the hook, I was in a hurry, and my unfortunate index finger on my right hand ended up inside the mouth of the rapacious fish. It took a healthy bite, and the blood began to flow from the wound. I had to put fishing aside and tend to the wound. This was of course letting the best time for fishing slip by. I caught no more fish.

On any ordinary day, one would not have to worry about such a trifling wound on the finger, but, in the circumstances, it was an entirely different matter. After all, in a few days we

had to blast off into space, and if my finger were inflamed, they might not let me go. My attitude toward the wound was therefore one of concern -- I washed it carefully and bandaged it firmly. /60

Vitaliy Ivanovich and my other comrades managed to catch rather a lot of fish during this time -- both pike and perch. Together with my fish, there were enough for a real triple fish soup.

There were many interesting conversations over the soup. Each fisherman, vying with the others, tried to tell about his own fishing adventures. My backup was the luckiest: he managed to hook and pull in the largest pike -- the "kingfish" of today's fish trophies. He was very proud of it. For my part, I caught more jokes than anything else; my unfortunate finger and the heroic pike which had so deftly left his mark to posterity were at the center of attention.

I love fishing and am always ready to go out in any company. Fishing is one of the best kinds of active relaxation. While fishing, one forgets about everything around him. All thoughts turn to fishing, especially when the fish are biting. If they are not biting, one can all the same dream serenely, make plans for the future, think about past years and everyday life.

I involuntarily remembered those distant years when I was a child and a youth, I remembered my native region, the village of Shorsheli, the Tsivil' River, which flows straight past our village and enters a great river -- the mother Volga. I remembered those wonderful sunrises and sunsets, when I was often out fishing.

However, my life has not always been so smooth and easy. I was still in school when the war began. Nearly all the men in the village went off to the front. Only women, old women, the sick, and the children stayed behind. My father did not go to the front, for he was gravely ill. He lay in bed for months. But as soon as he got up, he began working.

We little boys worked along with the adults. We harvested the rye and wheat, we threshed the grain, we stacked hay, and in the evenings we helped our mothers in the milking sheds. We cleaned them up, and we laid in fodder.

And we studied. It was never so difficult for us that we gave up our studies.

After a long and hard illness, my father died. All the cares about us fell on my mother's shoulders. Kind neighbors and fellow villagers helped us. The schoolteachers helped us. We ourselves felt grown-up, we worked and helped my mother not only at home, but on the collective farm. /61

I finished elementary school and went to study in the Mariinsk-Posadskiy School of Forest Technology. I received my diploma in 1947 and went to work on a timber concern in Karelia. From there, in 1950, I went into the army, where I got into aviation. I passed a course of study and became an air gunner. But I wanted to fly the airplane myself, with my own hands. I began to prepare myself to enter an aviation school. It was difficult, however, but I did prepare for the tests within a year, passed the physical, and was accepted into the Chernigov Military Aviation School for Pilots.

"Discipline, knowledge, and bravery -- these are the three bases which keep the plane up," our instructor, senior lieutenant Nikolai Koronets, told us in school. I have remembered these words all my life. Not only remembered, but followed.

My happiest day (before my space mission) was the day I first soloed. As I rose into the air, I could not believe it myself -- is it a trick, I am flying an airplane myself for the first time. I am in the forward cockpit. Alone. The plane is in my hand! It was as if I had been reborn. Everything around me seemed indescribably beautiful, joyful; it was as if the sun had suddenly begun to shine dazzlingly on an ordinary, dull August day, had begun to burn and pour out fiery rays.

And so I flew and flew. On different types of airplanes. On jets and MIG's of course. Indeed, I became a fighter pilot.

One day I was sent to the regiment's chief-of-staff. Two unfamiliar lieutenant-colonel's sat beside him. They asked, "How are thing?" I answered, "OK."

From the beginning, the conversation did not hang together. I did not understand what they wanted from me. They suddenly put the question straight to me, "Do you want to fly higher and faster?"

"What pilot wouldn't" Is this on new airplanes?" I asked.

"No, not on airplanes, but on space ships." /62

At first I was taken aback: "Really?"

"Completely. Not right away of course. First you have to pass a medical examination and then go into training."

"Yes, I will," I replied briefly.

Everything began with this. Ten years have since passed. I sit on the shore of a distant river and tomorrow ... tomorrow into space again, for the second time.

* * *

Meanwhile, in the technical areas of a special assembly-test building, they were finishing the assembly of the launch vehicle's units, attaching the spacecraft to the launch vehicle, and carefully checking the whole space rocket complex.

The Soyuz spacecraft is more advanced than the Vostok. It is marked by new design decisions which allow it to maneuver in robit, to rendezvous, to approach, moor, and dock with another spacecraft; and it makes it possible in space to carry out scientific experiments in a broader scope than the Vostok. I will try to teel in as much detail as possible about the structure of the Soyuz-9 spacecraft. It consists of three basic modules -- the orbital module, the command module, and the service module.

The orbital module of the Soyuz-9 serves as a laboratory for scientific research and experimentation. All the scientific equipment is placed inside it: the portable television camera, the movie camera with interchangeable lenses and a supply of film, a spectrography, a sextant, navigation instruments and equipment, and electronic-optical devices.

There are four windows in the orbital module; through them we made navigation observations, navigation changes, and movies and still pictures during the mission.

On the walls of the orbital module are places where the cosmonauts may secure themselves while they are doing various operations in zero gravity; and there are places for fastening /63
sleeping bags, both when they are rolled up and unrolled. It also has a couch for the crew to rest on.

The instrument panel is arrayed on a special convenience [servante] console, as are control panels for various systems, including the communication control. There is also a radio receiver here, which is used at the discretion of the crew. We turned it on during our free time -- while eating or washing up in the morning -- and listened to the latest news, sports broadcasts, and concerts.

Inside the convenience console, aids to personal hygiene are set out in small compartments: towels, linen, napkins, razors, and the onboard medicine chest. The food is set out in a separate compartment, and there are water and black-currant juice in special containers. Just above the convenience console is a food warmer.

Under the couch are the life-support assemblies: the regenerative installation, the carbon dioxide absorber, and the

cooling and drying unit. Closer to the ceiling are lights, which we used while taking pictures and doing television broadcasts.

A shock-absorbing gymastics area was laid out so that we could do our set of physical exercises; and special exercise suits were sewn in.

The orbital module of the Soyuz spacecraft can be used as an airlock chamber. So it was, for example, on the Soyuz-4 and Soyuz-5 missions, when Aleksey Yeliseyev and Yevgeniy Khrunov transferred from one ship to the other through space.

There is a hatch on the hull of the module so that the crew can enter for launch and so they can exit for space walks. We spent the greater part of our time during the mission in the orbital module. We worked there, ate there, rested there, and did our exercises there.

The command module of the Soyuz-9 spacecraft is designed to hold the crew while the spacecraft is being launched, while dynamic operations in controlling the spacecraft are being performed in space, and while the spacecraft descends to Earth. Its shape is similar to that of an auto headlight (whereas the Vostok had the shape of a sphere). The exterior of the command module /64
is covered with a special heat-resistant layer, which protects it from aerodynamic heat on reentry into the Earth's atmosphere.

The shape chosen for the command module -- a shape with a definite center of gravity -- allows it to make use of the aerodynamic lift force in the atmosphere (as they say, its aerodynamic characteristics). As the spacecraft returns to Earth, g-loads are significantly reduced. on the Vostok spacecraft, g-loads on landing reached 7-8 units; on the Soyuz, there are only 3-4 g's.

In the command module, an automatic system of controlled descent has been installed; its engines are placed about the outside of the module. This system controls the spatial position of the module during descent.

On the lower part of the command module are the soft-landing engines. They actuate near the Earth's surface and further reduce landing velocity. There were no such engines on the Vostok.

On the upper part of the module's hull is a passageway-hatch, which is designed so that the crew may take their seats in the command module, enter the orbital module, and exit the command module after the mission is completed. There is a radio antenna on the exterior to maintain radio communication with Earth during descent and landing.

On the Soyuz-9 spacecraft, the regular landing system is the parachute system. It consists of several parachutes, each one of which has a definite function. The parachute system is kept in a special container on the command module and opens automatically at a height of about 7000 m. This assures that the spacecraft will float down to Earth slowly.

In the command module are contoured seats for each of the crew members. The seat conforms precisely to the body configuration of the cosmonaut for whom it is designed.

The cosmonauts sit in these seats during entry into orbit and during descent. In orbital flight, they are also working seats. When all dynamic operations (orientation, turning toward the Sun, orbital correction, mooring, docking and others) in controlling the spacecraft are to be performed, the crew takes their places in the seats and fasten themselves in with a special seat belt system. /65

The seats are set at a definite angle in relation to the direction of forces acting on them, and they thus make it easier to tolerate the g-loads on entry into orbit and during reentry into the Earth's atmosphere.

The seats have special shock absorbers, which operate if the soft landing engines fail; they thus can reduce the g-loads on the cosmonauts.

The cosmonaut's seat has an intricate design. The radio sets, amplifiers, and a special system which attaches to the cosmonaut's headset are built into it. A speaking key is installed on it for radio communication with Earth. On the right and left of the center chair are the control levers for the spacecraft (low-thrust engines) and their locks.

The right lever serves to control the spacecraft's movement around its center of mass; the left serves to control the spacecraft's mass center itself. Beside the left lever is a toggle switch, designed to regulate the spacecraft's forward velocity. These control levers are used as follows: orient the spacecraft prior to orbital correction and descent, to orient the spacecraft so as to conduct tests, and to rotate the spacecraft. The spacecraft's commander uses these levers while mooring and docking with another spacecraft or with a space station.

Our Soyuz-9 was furnished with two work seats. In place of the third seat, scientific apparatus, movie and still film cassettes, a supply of magnetic tape, and instrument for biomedical experiment -- to be returned to Earth after the flight objectives were completed -- were installed.

A visual sighting device, which the crew uses while guiding and orienting the spacecraft, is installed on the body of the command module. To the left and right of the cosmonauts were two windows, which are used for observations, measurements, and photography. /66

In the command module, as in the orbital module, are the control devices, life-support systems, and a television camera. In front of the cosmonauts is the spacecraft's instrument panel, with its navigation instruments: a globe, which shows what place on Earth is being flown over; gauges of light and dark, length and width; instruments which show the period of the spacecraft's revolution around the Earth; and a clock, which gives precise Moscow time. The controls for the electric power supply and the life-support system are also on this panel.

In the middle of the panel is a panel of electroluminescent gauges which have to do with the operation of particularly important systems in the spacecraft. It indicates when the basic propulsion system is fired and cut off, when the micromotors are operating, when the automatic landing system is operating, when the radio sensors are operating, and it shows the air composition. Lower down is a combination visual display, which operates in several different ways. During mooring and docking, it acts as a television camera, on whose screen the linear and angular movements of the other spacecraft are monitored. When the parameters of the main engine and the low-thrust engine are being monitored, the crew can use this display to monitor the pressure of the components in each of the engine systems. By switching the display to "air composition," the crew can read the partial oxygen pressure and the carbon dioxide pressure in the cabin. Under the "orientation" mode, the display is used for automatic and manual orientation of the spacecraft.

To the right of the multipurpose electronic display is the program status indicator. It is designed to monitor the switching on of the programmer: the passage of time commands or a selected program from the programmer to the spacecraft's actuators.

On the right side of the instrument panel is a digital data block. It is designed for the input of "settings." The "settings" set the magnitude of the momentum and, in accord with this, the firing time of the main engine (which is cut in to carry out the maneuver program). The "settings" also determine /the angles by which the spacecraft rotates about its axes./ The main engine control switches are in the middle and lower part of the instrument panel. /67

On either side of the control panel are two signal-command devices. All the spacecraft's systems are controlled from here during the mission.

The regeneration assembly and the cooling and drying unit in the command module maintain normal partial pressures of oxygen and carbon dioxide, atmospheric pressure, and a specified temperature and humidity in the spacecraft.

The service module of the spacecraft is designed to hold onboard machinery, equipment and the propulsion system of the spacecraft.

In the pressurized part of the service module are the heat-regulation assembly, the instruments of the orientation and control systems, the electric power system, and the radio and telemetry equipment. In the unpressurized part of the service module is the liquid-jet thruster system. It consists of main and reserve engines, each with a thrust of 400 kg. The crew uses this propulsion system to make orbital corrections, rendezvous, and in descent from Earth orbit.

On the hull of the service module are the low-thrust engines. They are used for control during the mooring and docking of two spacecraft, while the spacecraft is being oriented in space, while it is being rotated, and also for stabilizing the spacecraft after it has been oriented and while the correction rocket is operating.

On the exterior of the service module are the solar batteries, which open after the spacecraft enters orbit. The solar battery panels are the basic solar energy receptors, and the devices which transform solar energy into electrical energy fed to the spacecraft. The antennas of the radio frequency system and telemetry are also located here. This is the design of our spacecraft, in brief.

* * *

The launch vehicle, which had been joined to the spacecraft and which had been checked carefully, is brought to the launch site on a special transport-erector assembly and placed on a platform -- the launch complex. A special service framework holds the rocket in a vertical position and allows the launch command team to carry out all operations in servicing the launch vehicle and spacecraft during the prelaunch period. The launch command joins the pipelines of the fueling and exhaust systems with the onboard and ground cable network. /68

Before beginning to charge the rocket with fuel and oxidizers, the fuel pipes and tanks are purged with nitrogen, so as to remove any traces of air and moisture; only then does the charging of the tanks with the fuel components proceed.

At the same time, the final check of all systems and assemblies of the space-rocket complex as a whole is underway.

Here on the launch pad, as nowhere else, do you feel more deeply the multifarious aspects of the process of mastering space which our country is doing -- the work of many groups of specialists. The work of scientists, designers, engineers, technicians, and workers, those who have designed and built the launch vehicles and spacecraft; the work of those who tested the intricate technology; the work of the launch team, who assure ignition and the insertion of the spacecraft into orbit. This is titanic labor on the part of men and women who are in truly heroic professions. They give all their knowledge, the strength, inspiration; they spend sleepless nights trying as best they can to ready the spacecraft for blast-off.

The mission of the cosmonauts only crowns their great labor. Preparing the spacecraft for its flight can be graphically compared with the construction of a huge pyramid. The cosmonaut in all this is the man who carries the last stone to the top.

Very few days were left before the launch of the Soyuz-9. Nothing was too minor in these tense days. We saw how our doctors worried when my finger was hurt slightly, and when Vitaliy developed a small abscess on his nose. They did all that was necessary to /69 assure that we would be in good shape, as they say, for the prelaunch medical examination. It is yet another, the last, careful medical examination. It showed that our health is excellent and our mood was cheerful. The doctors had no reservations.

On the eve of the launch, the State Commission convened in a festively-decorated hall. To this session came scientists, designers, and leading specialists -- those who had developed the spacecraft's and launch vehicle's systems and equipment -- and the specialists from the launch team at the space center. They were the ones who had readied the space-rocket assembly for launch, the ones who knew the status of its systems precisely. The medical specialists who monitored our health also came. Vitaliy and I, our backups, and the instructors who were responsible for training us for the mission were invited too.

The State Commission listened to reports about the readiness of the spacecraft, the launch vehicle, the launch complex, and the cosmonauts themselves. It reaffirmed the composition of the Soyuz-9 crew. I was named commander, and Vitaliy flight engineer.

Our reports to the State Commission were brief. We sincerely thanked them for the great trust shown in us -- to carry out an 18-day mission, the longest to date. We reported on our readiness to carry out the mission program and assured them that we will exert all our strength, knowledge, and experience to live up to the trust shown in us. The Chairman of the State Commission, in summing up the meeting, said that the mission will be difficult and crucial, that is will demand great will power and

concentration on our part. He congratulated us on our confirmation as crew members of the Soyuz-9 and wished us a successful execution of our assignments and a soft landing.

After the State Commission meeting, there was also a meeting with the chief designer. He told us about the final stage of prelaunch operations and about how everything was on schedule, with no malfunctions noted. He took a warm and fatherly interest in how we were, how we felt, and whether we had any doubts or unresolved questions. Once again we assured him that we were fully ready for the mission, that everything was clear, that everything was well understood; and we thanked him sincerely for his attention and concern. /70

A little later there was a meeting with newspaper, radio, and television correspondents. As always, they asked a lot of questions.

"What do you consider the most important thing in this mission?"

"The main thing is fully to complete our complicated and difficult flight program," was our answer.

"What does this program consist of?"

"The Soyuz-9 mission, in addition to the comprehensive testing of its systems, has the goal of checking the results of theoretical and experimental research done on maintaining the crew's active work capacity in prolonged zero gravity."

We are also to carry out an extensive program of scientific and technical tests and experiments, the most fundamental of which are: biomedical testing of the impact of space flight factors on the human body in Earth orbit, as well as of the behavior of the body after return -- during readaptation, i.e., readjustment -- to the Earth's gravity; the observation and photographing of geological and geographical features, the continental and marine surfaces of the Earth -- with the goal of development methods to exploit the data we receive in our national economy; the observation and photographing of atmospheric formations, the Earth's snow and ice cover -- with the goal of exploiting the data we receive in short- and long-term weather forecasts; research on physical characteristics, phenomena, and processes in near-Earth space; further refinement of manual and automatic systems for control, orientation and stabilization of the spacecraft in space, as well as to test the autonomous navigation devices in the various mission modes; tests of the Soyuz-9 systems new instruments for navigation and control; the determination of the design and dynamic characteristics of the spacecraft; an analysist of external disturbances; the accumulation of experience and statistical data for /71

greater reliability of the spacecraft's design and its actuators. During the 18-day mission of Soyuz-9, we are simultaneously to test the strength, reliability, and endurance of man and machine.

Our flight program is interesting, complex, and filled with research and experimental work. We are expected to give answers to hundreds of questions posed by those who designed and built the spacecraft and its systems, and by scientists and specialists in various fields of science. The results of our research and testing will serve not only to carry the study of space and our planet further, but also to develop our country's national economy.

In answer to the question of how Soyuz-9 differs from Vostok-3 on which I had flow 8 years earlier, I could give an entire lecture, but, because of limited time, I gave a short answer: for its time, the Vostok was a remarkable spacecraft, but the Soyuz is a more modern, multimanned spacecraft. It can perform a variety of missions; it has good facilities for the crew's work and rest; on reentry the g-load is half the g-load on the Vostok; and, of course, there is the soft landing. But I have already spoken about this. Yet one more question calls for detailed explanation. Which sciences are most truly directed toward the study of space? It is difficult to determine, for many, many sciences are concerned with this matter, which is so necessary to our national economy. Designers, development specialists, medical specialists, biologists, astronomers, geophysicists, meteorologists, geologists, geographers, and many other specialists want answers to the questions which interest them. We are to add to our present knowledge on the impact of space flight on the human body. We are also to observe and photograph geologic and geographic features. This is needed to develop our methods for using the data we receive in our national economy, particularly in discovering the natural resources and useful minerals of our planet. This is already a practical application of space research to our national economy. We get great practical use from the automatic communications satellites of the Molniya series and from the Meteor weather satellites. Our mission can compare their data with the data from direct human observation. In a word, our mission will truly be a working mission. We will do many scientific, technical, and biomedical tests and experiments. /72

To the question whether one can consider that the cosmonaut's profession is becoming commonplance, we gave a short answer. No, we do not agree that being a cosmonaut is an ordinary profession in complicated circumstances. It is still an uncommon profession. Above all, it requires certain physical data; in the second place, since the pioneering of space has just begun, we often have to face the unknown. Each mission is experimental. In time, of course, being a cosmonaut can become as ordinary as being a pilot is now.

We emphasized in our answers that in the future scientists from entirely different fields will be lifted into space on board a spacecraft. They can do fascinating and indispensable work to solve many problems of the national economy.

Ending the press conference, we wished the correspondents well as they comment in detail in the press, on radio and television as the space mission carries out its program. They in turn wished us a good launch, a successful execution of our assignment, and a safe return. We thanked them for their good wishes.

* * *

The long-awaited day came -- June 1, 1970 -- when Soyuz-9 was to blast off. We got up at 9:00 a.m. Moscow time (11:00 a.m. local time). Then we had a medical inspection, did light morning stretching exercises, and ate breakfast. Then we again read carefully through all the notes in our flight logbook, where the entire program of the mission was written out according to days, hours, and minutes. This logbook was rather large -- about 500 pages. Once more we thought through what we would do from the moment we entered the spacecraft to the time we entered orbit. /73

The time before lunch flew by unnoticed. The day's agenda had rest schedule for after lunch. We slept soundly for 2-1/2 hours. Vitaliy did not even hear the alarm clock. We had to wake him so that he would not miss his long-awaited launch into space.

In the little house near the launch pad, medical specialists put the space suits on us, as well as the medical harness with its sensors to monitor our physical indices during the mission. Then they put on our underclothing flight suit. There and then they gave us the identity card of a Soviet pilot-cosmonaut.

Before leaving for the launch pad, we ate supper with gusto. They served us beefsteak, fried potatoes, milk, butter, cheese, rolls, and strong tea.

Taking with us our logbooks, souvenirs, photos, Komsomol pins from the youth of the space center, and the emblem of the Komsomol Central Committee, and saying goodbye to friends and comrades, we got in a specially-equipped bus and set out. Although the road was short, we, our backup friends, and the comrades who accompanied us managed to sing our traditional space song, "The Spacemaps are in Their Cases."

At precisely the appointed time our bus arrived at the launch pad. It was already night, but it was as bright as day all around. The bright lights of the searchlights shone on the launch vehicle. This snow-white beauty stood majestically, aimed at the dark night sky.

Our bus stopped near a group of people: the Chairman and members of the State Commission, the Chief Engineer, scientists, those in charge of our training, and representatives from the launch command.

We said goodbye warmly to our backups and those who had come along, got off the bus, and turned toward the Chairman of the State Commission. We stopped three steps in front of him, and I reported, "Comrade Chairman of the State Commission! The crew of the Soyuz-9 spacecraft is ready to carry out its mission. /74
Permit us to take our places in the spacecraft. Colonel Nikolayev, Soviet aviator-cosmonaut, spacecraft commander."

The Chairman of the State Commission accepted my report, wished us a successful completion of our flight objectives and a safe return to Earth, and allowed us to take our places in the spacecraft. All those present also wished us a successful mission. We thanked them for their good wishes and said goodbye. We went into the elevator, and it took us to the top of the launch vehicle, from where we again waved to our friends and everyone who had come with us. We then entered the spacecraft.

We settled comfortably in our seats. We pulled out our seat belts, put them one, and fastened them. We attached the medical sensors to the spacecraft's onboard system. We established two-way radio contact with "Dawn" (ground control). We reported that the hatch was closed, that the medical harnesses were attached, and that we had taken our places. "Dawn" received our report and allowed us to begin our preflight check of the spacecraft's systems and equipment.

By now the specialists from the launch command had finished fueling the launch vehicle and had completed the final prelaunch preparations. As the work proceeded according to schedule, the loudspeakers announced 2 hours and counting, then an hour, 30 min, 15 min, 5 min, and 1 min. By the 5-min mark, we had finished checking all the spacecraft's systems and equipment. Their status matched the initial data. The check revealed nothing out of order. At 5 min and counting, we reported to "Dawn" that we had finished our check of systems and equipment and that there were no problems. Then we firmly fastened our seat belts and secured ourselves. All the while we felt fine. "Dawn" received our report and turned on the onboard television camera. We made a statement prior to the launch: "Dear comrades and friends. Today our Soyuz-9 crew is leaving on a journey into space to continue the important task of pioneering space for the national economy, science, and technology.

"Our country is doing systematic work to open up space. On /75
Soyuz-9, we are taking the next step in our program of scientific and technical research and experimentation.

"We will do everything required to carry out successfully the assignment given to us. Goodbye, comrades. Until we meet again on Earth!"

From the moment we took our seats inside the spacecraft, we were in continuous communication with ground control ("Dawn"). Anatoliy Filipchenko, pilot-cosmonaut of the USSR, was on the line. He had been commander of the Soyuz-7 and himself had experienced the anxiety connected with the launch. He observed us on the television and gave practical advice in a quiet voice.

"'Falcon', put the logbook in place and fasten it down. Everything will be in order. Your parameters are good. Keep it up."

"I hear you. This is 'Falcon.' All normal on board."

The first launch command is given "Switch to launch." This means that the circuits ensuring that all engines of the central and side units of the launch vehicle which fire simultaneously are turned on.

The next command: "Tape transport one." On this command, the telemetry recording tapes begin turning, and the parameters of all assemblies and systems of the launch complex are recorded.

On the "Purge" command, all fuel lines and ignition chambers in the propulsion systems are purged with nitrogen. On the command "Ventilation," the fuel tanks are ventilated, and the pressure built up by the fuel vapor is relieved. On the "Switch on exhaust" command, all exhaust valves are closed, and the make up feed of the fuel tanks ceases. The closing of these valves is heard clearly in the cabin. On the "Launch" command, the fuel tanks are purged with nitrogen, and an excess pressure is built up inside them. By now the space-rocket complex is fully ready for lift-off.

After the "Launch" command, the tormenting seconds drag on slowly. Next is the "Tape transport two" command. A second telemetry recording tape is started up, wherein the full readiness of all systems and assemblies of the complex as a whole is ascertained.

On the next command "Ground to spacecraft," the cable connections are disconnected, and the main cable is taken away. The purge of the fuel lines is completed. The main fuel valve opens, and then the oxidizer valve. The fuel components begin to enter the engine ignition chambers. /76

The "Fire" command is then given. On this command there is ignition, and the plume exhaust shoots out of the engine ignition

chamber. We cannot see it. But we clearly hear the command given, and we can well imagine how it looks from outside the spacecraft.

The engines fire at a preliminary, intermediate intensity and then at full power. As soon as the thrust of the engines exceeds the weight of the entire system, it begins to rise slowly. The lift contact is triggered, and thereupon the last command "Lift-off" is sent over it. This triggering of the "Lift-off" contact determines the exact moment the space-rocket system is launched.

We gather speed and height. "Higher, higher, higher..."

PART 2. IN ORBIT /77

And so, our journey into space has begun. In the earphones of our headsets sounds the clear voice of "Dawn": "Engine parameters normal, engine working smoothly." We hear the time counted off: "Ten, twenty, thirty, fifty seconds," and again, "Parameters normal, engine working steadily."

I report back to Earth: "Dawn, this is Falcon, all normal on board, we feel a small jolting and a slight vibration from the engine, g-load is gradually increasing, we feel fine."

"Roger, Falcon, all normal, the engine is running smoothly," Dawn answers.

The g-load increases as the engines operate. The first stage of the launch vehicle separates, and now only the second stage is operating.

When the nose shroud was dropped, we caught sight of the dark night sky, where the stars were shining brightly, through the windows. We reported to Dawn that the nose shroud has been dropped.

The second stage fired the allotted time and then cut out. We clearly noted the firing of the third stage engine, which continued to accelerate the spacecraft until it reached the velocity necessary to put it into Earth orbit.

I should mention that the increasing g-loads did not cause us any unusual sensations -- we had become used to it while training on the centrifuge back on Earth. After all, the centrifuge had been rotated in a pattern that had simulated the g-loads caused by the acceleration of the launch vehicle during powered flight. /78

The third stage engine, which had imparted orbital velocity (about 8 km per second) to the spacecraft, cut out, and the spacecraft was separated from the launch vehicle. At separation we felt a jolt, and then silence descended upon us.

Anatoliy Filipchenko, after completing his mission on Soyuz-7, described how he had felt when the spacecraft separated from the last stage of the launch vehicle. At this moment I remembered his words: "A burst, and then it is as if you had fallen out of your seat and turned upside down, with your face toward the Earth, and hanging by your seat belts. This sensation occurs because the pressure on the spine disappears. A complete silence reigns. The onboard clock begins to tick unexpectedly loudly. Luminous particles sparkle outside the windows." Now, I was experiencing approximately the same sensation.

Our Soyuz-9 spacecraft entered the Earth orbit of an artificial Earth satellite as planned. We did not conceal our joy. We congratulated each other.

* * *

The spacecraft flies on in the darkness of space. It is light inside the cabin. But it is dark in the windows. Only a new moon and the stars talk lazily to each other, in a secret language unknown to man. But the stars are not our concern. Our work is beginning.

The programmer fired the small attitude-control jet engines of the spacecraft and quickly slowed the angular velocity rate, which had been imparted to it when the launch vehicle separated. To make our work comfortable, we loosened our seat belts a bit.

But now the spacecraft has left the darkness and is now on the Earth's light side. This is my second time in orbit, and I greet the sunrise calmly. But Vitaliy is a novice in space, and he saw his first space sunrise with exaltation.

"Andrey," he exclained, grabbing me by the arm, "look, oh, what a sunrise there on the right. A tremendous sunrise! Look, what a sun. It is coming straight at me! The Sun is drifting straight at me! Incredibly beautiful!"

His ecstasy was understandable, but all the same I said, /79
"We will yet get to admire it to our heart's content; than many sunrises we have before us! But now -- to work!"

Then the last stage of the launch vehicle appeared in the right side window against the backdrop of the Sun and the cosmic sunrise. I quickly got the camera and passed it over to Vitaliy, so that he could capture this moment on film. Vitaliy took a few pictures, but, as it later turned out, nothing showed up against the bright background of the dawn.

We did a visual check through the windows of the command module to see whether the solar batteries and radio antennas had deployed. They all had deployed as they should. On the UHF and and short wave exchanges we established two-way radiocontact with Earth and made a report to Dawn: "The time of the spacecraft's separation from the launch vehicle -- 22:08:51. The clock and the "globe" are working. The spacecraft has quickly become quiet. The solar batteries and antennas are deployed. All in order on board."

Dawn received our report and congratulated us on our insertion into orbit. They wished us a good flight and a successful completion of the mission program. They gave us our orbital

parameters immediately: minimum altitude (perigee) -- 208.0 km, maximum altitude (apogee) -- 220.6 km, period -- 88.58 min, and inclination -- 51.7°.

As was specified in the flight program, we began checking the status of the spacecraft's systems and equipment. We turned on the combination visual display, which showed the magnitude of the fuel-oxidizer supercharging pressures in the thrusters and attitude control engines. Everything was normal. The display also gave us the air composition in the cabin of the spacecraft: partial oxygen pressure -- 160 mm mercury, carbon dioxide -- 4 mm mercury, and 60% humidity. Then we checked the pressure and temperature. The pressure was 800 mm mercury. The air temperature was +25°C in the command module and +24 in the orbital module. We checked the command-signal device, the electroluminescent signal system and the program status indicator. Everything was in order. We checked the operation of the life-support systems in the command and orbital modules by looking at the readings of the gauges: the gas analyzer, the drier, the conditioner, and the cooling and drying units. /80

This check showed that all systems and equipment were working properly. We noted nothing wrong in the spacecraft.

The time passes surprisingly quickly on a space mission. As we were checking all systems, it came time to turn the spacecraft toward the Sun. At the assigned moment (30 minutes after insertion into orbit), we began performing this operation. We selected the proper attitude-control jet engines on the command-signal device and turned on the spacecraft's angular velocity and manual orientation sensors. By firing the attitude-control engines and using the control levers, we oriented the spacecraft with its solar battery panels deployed toward the Sun. We turned the spacecraft on its orientation axis. Turned this way, neither the spacecraft nor the gyroscope changes its position in space. The solar batteries will now be turned always toward the Sun, which assures that the buffer batteries will continuously be recharged. Indeed, the voltmeter had already begun to show a current in the circuit: its current -- 25 amperes, the voltage -- 32 volts. Here agin, everying was normal.

We checked the pressurization of the spacecraft's orbital module and equalized the pressure in the command and orbital modules.

We freed ourselves, entirely from our seat belts, opened the hatch of the command module and stepped into, no, not stepped into (as on our trainer on Earth), floated into the orbital module. Here we checked all instruments and equipment. Then we set out the scientific equipment cases and began further to carry out the flight program.

* * *

When we reentered the zone where we could communicate with our ground stations, we at once heard in our earphones the familiar and nearby voices of our friends and comrades who had stayed on Earth, the head of our Soyuz-9 mission.

We reported to Earth about the operations we had carried out /81
on our first revolution: i.e., about turning the spacecraft toward the Sun, about the normal functioning of all the spacecraft's systems and equipment, about our entry into the orbital module, about how we were feeling, and about the fact that we had begun performing the program planned for the mission.

Earth received these messages and gave us the information we needed to continue our work on the flight program.

While still on the launch pad, we had been told that on the day of our launch -- June 1, 1970 -- the first man to set foot on the Moon, the American astronaut Neil Armstrong, was to visit Star City. Now, in orbit, we receive a radiogram from him with warm congratulatory words: "Very best wishes to the Soyuz-i crew, success in carrying out your flight objectives, and the best of landings. Space City. Neil Armstrong." It was of course quite pleasing to receive the congratulations of our American colleague. Vitaliy and I sincerely thanked Neil Armstrong for his congratulations and good wishes.

Earth was interested in how we were getting used to weightlessness.

We cheerfully answered -- normally!

The various complex training we had done before the mission was not in vain. Our adaptation (adjustment) to weightlessness was relatively easy. To be sure, in the first part of the mission we, like the other cosmonauts, had felt a rush of blood to the head, which in turn cause the face to puff up slightly. But the sensation was familiar to us, for we had experienced it while still on Earth. At the space center we had slept with our feet higher than our heads. We had become used to it, and it did not prevent us from working normally. In space, moreover, if one "stands on his head," i.e., not on the floor but on the ceiling of the orbital module, the sensation disappeared almost completely. Why? Because the body was turned toward the Sun. Although these forces were hardly noticeable, the blood nonetheless flowed from the head to the feet.

In the first days of the mission, we had unpleasant sensations also while doing various physical exercises connected with deep bends of the trunk and head forward and back. However, these /82
sensations soon stopped. What else can be noted?

In our first hours in zero gravity, as we did various operations, moved about the spacecraft, or moved this or that object, we did not always calculate the strength of our impetus accurately. After moving about, we secured ourselves (fastened ourselves down) primarily by using our hands; only then did we find a support foroour feet. But later on, the support functions of the feet were restored. Our feet themselves, unnoticed, automatically began to act as braces, and as we moved about the spacecraft to do one thing or another, we stopped wherever needed.

Our observations and those of Earth confirmed that there were no abnormalities in our motor systems. Nor were there any disturbances of our motor coordination; a high work capacity was maintained. To jump ahead a bit, I can say that it was so throughout the entire mission: weightlessness did not prevent us from working!

The program provided for a rather large volume of work even during the first days of the mission, and we did not notice how the time flew by and the moment came for our first television report from space to Earth.

This took place at the beginning of the second day of the mission on the nineteenth orbit.

Because the spacecraft passed rapidly over the area in which ground control stations could receive television signals, there was always a limited amount of time for television reports, and naturally our reports themselves were extremely brief.

Vitaliy did the first report. He told the television viewers about our spacecraft's television system.

Here is what he said, quoted almost in full!

"The television system of Soyuz-9 consists of two television cameras placed on the outside of the spacecraft and one portable camera in the orbital module; the latter is being used for this report. A small screen on the instrument panel allows us to monitor our report. On the spacecraft's signal-command device, there are switches for turning the television equipment on and off, and for automatic changes of light filters and television camera lenses. /83

"By using the outside television cameras we can observe Earth and note conditions outside the spacecraft. The crews of Soyuz-4 and Soyuz-5 used the same cameras to monitor the rendezvousing, mooring, and docking of the two spacecraft.

"The portable camera serves to show all the spacecraft's modules, its interior, equipment, and the work of the crew. It

also allows us to transmit pictures of Earth made from space, that which we see through the window, to mission control stations.

"We are now flying in the Earth's shadow. Unfortunately, therefore, we cannot show a view of Earth from this window. But if we were on the Earth's lighted side, we could then show the Earth's bright-colored horizon and the luminous Earth itself. We will try to do this in our next report, which we will be doing during the day. Now I give the camera to Andrian Nikolayev."

I took the camera from Vitaliy and said:

"This is Falcon. Vitaliy has described our spacecraft's television system. I am now training the camera on him, and you see him on your television screens. He looks great, smiling all the time. His mood is excellent.

"Our lunch is now heating up in our food warmer. After finishing our communication with you, we will go into the orbital module -- there we have a space dining room."

Our first television report ended with this. What more can be said about our space television and radio communications?

When I was in Vostok-3 for the first time, I also made television reports from space. However, everything then was not as it is now.

First, there was no portable television camera. Indeed, it was not necessary. Vostok had only one module, and only one person was in it.

Second, the report went through internal channels only: between the spacecraft and the control center. But now we can /84
make direct reports from space. Why? Because reports from Vostok were transmitted on a frequency that differed from those of the standard broadcast network. The Soyuz's television equipment allowed us to transmit within the range of the general television network -- 625 lines and 40 frames per second.

All this certifies the increased capabilities of the new Soyuz spacecraft, which carried more intricate television transmission systems.

One more comment: if the television reports were limited to the area where ground stations could directly pick up signals, we nonetheless could maintain radio communication with Earth at any time, if necessary.

When we passed out of our territory and left our zones of communication, we usually rested, but if urgent communication with Earth was needed, we could always transmit our messages and

receive information from Earth through the Molniya-1 communications satellite and the ship Kosmonavt Vladimir Komarov, which was then cruising in the Atlantic Ocean.

This ship is a genuine floating scientific-measuring mission control station. It is 150 meters long and more than 30 meters high. It has more than 1000 rooms, all of them with artificial climate control. Its laboratories are equipped with modern scientific apparatus for measuring the trajectories along which spacecraft and space stations move. It has antennas for telecontrol of space objects, and for receiving and processing telemetry information. Its laboratories have sophisticated navigation equipment and space communications equipment. It is an all-purpose ship. It is able to maintain communications with several spacecraft at the same time. It can receive information from one spacecraft on one antenna and at the same time, using another antenna, it can transmit it through the communications satellite to ground control center.

Other ships, such as the Akademik Korolev and the flagship Kosmonavt Yuriy Gagarin, both of which are equipped with modern scientific and technical equipment and measuring devices, also took an active part in safeguarding space missions.

In addition to the Kosmonavt Vladimir Komarov, its "younger brothers" -- ships of the expeditionary fleet of the USSR Academy of Sciences -- were in the Atlantic and Indian Oceans: these were the Nevel'; the Kegostrov, the Morzhovets, the Dolinsk, the Ristna, the Bezhitsa, and the Borovichi. /85

These ships of the Academy of Sciences expeditionary fleet were to secure information, reception, and control of the spacecraft from the areas which were outside the radio range of the ground stations within the Soviet Union.

Our next television report to Earth was a day later, during the thirty-fifth orbit. I did this report and told the television viewers about the design of the spacecraft's control panel. Our readers are already familiar with this.

Another day later, during the fiftieth orbit, we had an interview with newspaper, radio, and television correspondents. They did not leave us in peace, even in space. They asked the inevitable questions, which I cite almost in entirety:

"Andrian Grigor'yevich, you are now in space for the second time. What new sensations have you experienced?"

I answered:

"I went into the first mission without knowing the conditions in space or prolonged weightlessness. In going to my second

mission, I was already familiar with all these circumstances. Everything was familiar to me. I knew myself and my body. I knew all the fine points of the body's adaptation to weightlessness. My experience from the first mission helped me a great deal, and it still helps me now.

"I have become used to the weightlessness as quickly as I did on the first mission. My overall sensations on this mission are about the same as before; there is nothing particularly unusual. On the Vostok, of course, it was a bit boring to be alone in the cabin. Here there are two of us. The work always goes better with a comrade on board. There is someone to consult with, you feel him at your side, and you know: in a difficult moment he can always come to my aid. We always come to an agreement with each other on all questions, we consult with each other, and we help each other out."

"Thank you, Andrian Grigor'yevich, now the second question: /86 compare the extent of the programs of your first and second missions."

"On Vostok, the mission program was interesting enough. Especially unbuckling, leaving my seat, and floating freely about the cabin. But now, the program is more extensive. We do many scientific, technical, and biomedical experiments, much research, and many tests of systems. We perform interesting dynamic operations in maneuvering and orienting the spacecraft."

"Andrian Grigor'yevich, we have one more question for you. You flew on Vostok. What can you say about the work facilities of Soyuz in comparison with those of Vostok, and what are the capabilities of the new spacecraft?"

"Soyuz has more advantages than Vostok. Soyuz is a spacecraft of a completely new type and generation in the development of space technology. It allows us to resolve broad tasks in the opening up of space: to perform complicated maneuvers in orbit, to search and rendezvous, to moor and dock with another spacecraft. Much interesting research can be done on it while in space. It is multi-manned, and there is still one more seat for a third crew member. But our flight program calls for only two men.. Our spacecraft has all facilities for normal work and relaxation. Right now you yourselves can see its conveniences on the television screen. To all that has been said I can add only one thing: during the entire mission on Vostok (4 days), I was in a space suit, which strongly restricted all activities and hindered work. But here we are not in space suits. Nothing interfered with our work, nothing cramps it, nothing limits it. It is like home -- easy and pleasant. One delight is that here you float like a fish in water."

"Falcon, this is Dawn. Our thanks for the description. The entire press center is here, and the correspondents as well, six of them. They all express their gratitude."

"Thank you. Give our greetings to them and our best wishes in their work, which is likewise not easy."

"I will do it without fail. But we still have 5 minutes left. /87 The correspondents are anxious to ask Vitaliy Ivanovich several questions."

"Go ahead, Dawn. Vitaliy is at your service. He is ready to answer the correspondents' questions."

"Dawn, this is Falcon 2. I am ready and await your questions."

"Vitaliy Ivanovich, how quickly did you get used to weightlessness? How is your work coming along?"

"I am slowly getting used to is, but I cannot say that I am completely adjusted to it. My associations are still earthbound, and I feel that everything around me is foreign. But I am working well and comfortably. Here, you dive here and there like a fish among the pebbles. Much more time is needed here than on Earth to do individual operations, especially manual operations and any kind of experiment. That is because it is necessary to fasten everything down. You get the logbook, make an entry, put it down, and right away you have to fasten it down so it does not float away. You forget and chase the logbook all over the cabin. Because of such locking-down procedures, you lose much more time here than on Earth."

"Thank you, Vitaliy Ivanovich, we have another question for you. How fully have you managed to use your technical knowledge during the mission?"

"Well, this is a difficult question. I think that knowledge is needed to control any technically sophisticated instrument, assembly, equipment or machine, let alone a spacecraft, where you need special technical knowledge. Both my commander and I have this knowledge to the necessary degree, and we try to use it so as successfully to carry out the flight program."

"How is your spacecraft responding?"

"Soyuz is a clever machine and responds excellently. It is easy to control it. The control system is working reliably."

It was not accidental that the correspondents raised the question about controlling the spacecraft.

Our extended experimental mission on Soyuz-9 was pursuing many different and important goals. I have already spoken about one of them -- to determine whether it is possible for man to spend long periods of time in space. /88

The second and no less important is the experimental testing of the spacecraft's and crew's capabilities of doring various dynamic operations in orbit: to orient the spacecraft, stabilize its flight, correct its orbit, maneuver, and others. After all, it had been proposed to use Soyuz in the future as a transport ship to take crews to a permanent orbital space station. To get ahead of my story again, I note that already in April 1971, the crew of V. Shatalov, A. Yeliseyev, and N. Rukavishnikov was launched into space on Soyuz-10; they docked their spacecraft with the Salyut station. Then, in June 1981, Soyuz-11 put a group of space researchers on board Salyut: G. Dobrovol'skiy, V. Volkov, and V. Patsayev.

However, it was first necessary to complete the series of preliminary space missions, begun on Vostok and Voskhod, and continued on Soyuz spacecraft, with a great deal of experimentation and testing of space technology. These missions practiced and refined the spacecraft's various maneuvers and tested the space navigation systems.

I should comment that flying and controlling a spacecraft differs in many ways from flying and controlling an airplane.

An airplane fies in the relatively dense layers of the atmosphere. Its plane surfaces rest on the air while flying. Its engines work continuously, and their energy is expended to overcome air resistance and create lift forces.

A spacecraft flies above the atmosphere, or, more accurately, in its topmost layers, where the density of the gaseous environment is a millionth part of the density of the atmospheric layers closer to Earth where airplanes fly.

A spacecraft encounters no air resistance and flies with the great velocity the launch vehicle has imparted to it, i.e., about 28,000 km per hour or about 8 km per second.

Special ailerons or flat vertical and turn rudders control an airplane. The pilot changes the position of these rudders in relation to the airflow, forcing the airplane to soar upward, dive, turn left or right, to do wingovers, barrel rolls and other maneuvers. /89

When an airplane does a "candle," flying straight up, the pilot feels a g-load: it presses him into his seat. He feels a g-load also as the plane turns one way or the other. He puts the

the plane into a dive, and for fractions of a second it is as if the pilot were without weight. The airplane's speed increases, it trembles and vibrates all over from the strain. The strain is transmitted to the pilot, and he merges with the machine, as if he had become one with it.

The cosmonaut who pilots a spacecraft has different sensations. During powered flight, during insertion into orbit, he like the airplane pilot feels g-loads, only stronger and more long-lasting.

After a spacecraft separates from the launch vehicle, weightlessness immediately ensues. If the airplane pilot feels it for fractions of a second, the cosmonaut is weightless for many tens and hundreds of hours -- nearly all the time the spacecraft moves along its assigned orbit.

The velocity of a spacecraft is ten times greater than that of an airplane, yet the cosmonaut barely fells it. It is quiet inside, there is no vibration, the roar of the engines is not heard, nor the whistling of the wind. Only the clock ticks, and the fan whirs. If you don't look out the window, it seems as if the spacecraft were generally motionless.

In constract to an airplane, a spacecraft has no flat rudders; they are of course useless in a vacuum. Their place is taken by thrusters, with whose help the spacecraft is controlled in flight.

A spacecraft, like an airplane, is very responsive. In an airplane, however, each movement of the control levers requires a definite effort on the part of the pilot; yet in the spacecraft, no particular effort is needed. The spacecraft submits easily to the cosmonaut. We say, "It follows the lever": it turns whichever way you push it. No g-loads occur during these turns, and the cosmonaut may note them only visually -- by the instruments or by /90
the movement of the Earth, Moon, stars or planets which are in the field of view from the spacecraft's windows.

The spacecraft's main engine, which has a thrust of 400 kg, is fired to slow down or speed up, that is, when the spacecraft goes into a new orbit. The cosmonaut feels its operation clearly and physically. All these features in controlling the spacecraft and the dynamics of its motion in orbit demand special skills from the cosmonaut.

The first Vostok spacecraft could not do complex maneuvers in space.

When I was still on Vostok-3, a second spacecraft, Vostok-4, piloted by Pavel Popovich, was inserted into orbit 24 hours after my launch.

The scientists, ballistics specialists, and the launch command handled their assignment brilliantly, and our spacecraft approached each other to a range of 5 km. We saw each other. However, neither Pavel Popovich nor I could bring our spacecraft closer together, not matter how much we wished to do so. Since our spacecraft had slightly different velocities, they moved apart after a while, and we lost sight of each other.

The Soyuz spacecraft is the latest word in space technology. It can perform complex maneuvers in space. G. Beregovoy twice during his mission brought his Soyuz-3 close to the unmanned Soyuz-2. V. Shatalov and B. Volynov docked their Soyuz spacecraft together, thus forming the world's first orbital station, and A. Yeliseyev and Ye. Khrunov walked across space from one spacecraft to another.

You obviously will recall the complex maneuvering the entire squadrom of Soyuz-6, 7, and 8 spacecraft did while in orbit.

Now we are to continue testing the Soyuz spacecraft, to perform a series of dynamic operations and test new systems of space navigation.

Soyuz-9 was equipped with a whole series of new instruments, with whose help the cosmonauts can determine the various elements of the spacecraft's orbit, define its position in orbit precisely, /91 predict the spacecraft's motion, determine the attitude control jet engine's impulse capability. On the basis of this information, we can do a series of orbital maneuvers manually.

The onboard sighting device allowed us to orient the spacecraft precisely in relation to Earth, the Moon, and the Sun. A still greater precision (to several angular minutes) was attained while orienting the spacecraft toward stars.

Maneuvering, orienting, and turning the spacecraft -- everything that has to do with the operation of the jet engines -- required the use of fuel. On an extended flight with many dynamic operations, it was necessary to be very economical. Strict rules were set down for this. For example, an orientation was maintained basically by minimal, single burns of the engines.

Almost every day, the solar batteries were oriented toward the Sun; the spacecraft was turned as well. To accomplish this, the spacecraft was first oriented correspondingly and then stabilized in this position by creating a rotation around the orientation axis (turn). All turns were done manually.

During the mission, the spacecraft was oriented several times toward the stars and toward Earth over its light and dark sides. In achieving and maintaining an orientation toward the Earth's

dark side, we used the night stratum of the brightness of the horizon as a reference point. By using this, we oriented the spacecraft along its pitch and roll axes, and we kept on course by using illuminated reference points on Earth. If the Earth was illuminated by the Moon, orientation of the spacecraft over the dark side of the Earth was greatly simplified.

During the mission we tested a series of new instruments which were designed to be used in the future in the orientation and control of spacecraft. We tested in particular the control of the spacecraft as it was ina solar-oriented attitude at various specified angles; this we did using a wide-angle visual display. This instrument turned out to be very convenient.

During the mission we also developed the methodology of optimal control of the spacecraft -- again with the help of this display. We used this method while doing so-called "oblique" turns of the spacecraft toward the Sun. Such turns were done while orienting the spacecraft at a definite angle to the Sun, so as to maintain normal conditions for the operation of the buffer solar batteries during periods of relatively small electrical use on board the spacecraft, and also to assure that the necessary heat conditions were maintained in the spacecraft. /92

During the mission, several corrections were made in the spacecraft's orbital motion. They, like a series of other dynamic operations connected with theorientation of the spacecraft, are done under both manual and automatic control.

The first correction was to increase orbital altitude and was done at the end of the fourth and beginning of the fifth revol revolutions.

Using the control levers and watching the Earth through the visual sighting device, we oriented the spacecraft so that the impulse capability was directed to accelerate the velocity. Then we turned on the gyroscopic instruments, and they kept the spacecraft in the new attitude.

Before firing the attitude-control jet engines, we once more checked the spacecraft's orientation, and, seeing that it was correct, fired the attitude-control engine at the calculated time. It fired for the specified time, and thus gave a thrust calculated to elevate the orbit. As a result of this operation, the spacecraft entered a new orbit, whose parameters were:

perigee -- 214.5 km
apogee -- 259.8 km
period -- 89.08 minutes
inclination -- 51.7°.

Thus, the perigee had increased 6.5 km and the apogee, 49.2 km.

However, in an Earth orbit, it is better to have an orbit close to the circular. If the orbit has an extended (elliptical) shape, then the spacecraft at perigee will be slowed even by the highly rarefied atmosphere at this height. The atmospheric density depends on the time of year. It is denser in winter than in summer. Since our mission was in summer, the atmospheric density had not great effect on the orbit of our spacecraft. All the same, however, we made a second correction, as had been planned, on the seventeenth revolution; this was to make our orbit more circular. /93

By making these two corrections, our orbit was as follows: apogee -- 266.1 km, perigee -- 247.8 km. This orbit allowed us to make a prolonged flight with no additional corrections.

I shall jump ahead and describe our third correction. It was on the twelfth day of the mission and was done in order to test the automatic orientation and control systems of the spacecraft. The spacecraft was oriented in such a way that its engines gave an impulse capability to slow the spacecraft. We fired the engine for a short time only to check its operation.

As I have already said, each manned flight and each refinement of all systems of the spacecraft, from the design to the space suit, have a direct bearing on the problem of building orbital stations.

Orbital stations, in addition to performing a complex of scientific and technical research, will be experimental bases for the development and testing of many designs and systems of space technology (engines, energy facilities, control and orientation systems, life-support systems, mooring and docking systems).

The building of orbital stations and equipping them with all that is necessary, and also the resolution of many other problems, above all demanded the development of free maneuvering in space by spacecraft.

We developed a series of promising elements of such a system. It allowed us to maintain any angular orientation of the spacecraft, any orientation required for the performance of scientific and technical experiments and for maneuvering.

For example, here is how we handled the spacecraft's manual orientation apparatus in relation to the stars Vega (in the northern hemisphere and Canopus (in the southern hemisphere).

The moment the spacecraft entered the Earth's shadow, we looked among the stars for Vega -- this is one of the brightest /94

stars of the northern hemisphere. Using the manual orientation system and the visual sighting device, we brought Vega into the view of the star sensor. The sensor "caught" the star and gave a signal by which the spacecraft gyroinstruments locked on the star.

In order to reduce the illumination of the star sensor by the spacecraft itself, and, in particular, by the solar batteries, Control Center instructed us to orient the spacecraft with its star sensor in the shadow of the solar batteries before we did our next experiment, this with Canopus. This allowed us to carry through the experiment in more favorable conditions and receive better precision characteristics from the instrument.

The experiment with Canopus was on the 176-178th revolutions. Canopus rose above the Earth's horizon 10 minutes before the spacecraft came out of the Earth's shadow. By using the aforementioned method, we brought Canopus into the star sensor field of view. Then we locked the precision characteristics of the instruments on Canopus.

These experiments allowed us to determine the brightness characteristics of the stars Vega and Canopus, as well as the characteristics of the new automatic sensors for locking on stars, a sensor which assures a reliable and precise orientation of the spacecraft against a background of strong light interference.

The results we got will be studied and used to work out and design new and better navigation instruments, with which new spacecraft and orbital stations will be furnished.

The tests of the visual optical electronic instrument which assures manual Earth orientation while flying over the dark side of the Earth and over the terminator (the border between light and dark on the Earth's surface) also went well. Up to that time, the orientation of the spacecraft on the shaded side of the orbit, i.e., when the spacecraft is in the Earth's shadow, had presented great difficulties. For this, we had used ionic sensors, which worked reliably in the light, but, because of "ionic holes," did not do so in shadow. During the flight and while on the dark side of the Earth and on the terminator, we oriented the spacecraft toward the Earth several times using the new instrument. The tests of the instrument gave good results.

During the mission we did a series of experiments on de- /95
developing autonomous navigation means and methods. In particular, we determined our orbital period and measured the altitude of our spacecraft's flight.

While on the 96th revolution, we did an experiment in determining orbital parameters with onboard equipment. For this, we chose Lake Viedma in South America as a ground reference point.

We oriented the spacecraft with its window toward Earth, made the necessary navigational measurements, put them into a numerical formula, and calculated one of the spacecraft's orbital parameters.

With the help of a special new sextant, we made a great number of measurements of the height of the stars and other celestial bodies over the Earth's day and night horizons and over the luminous layer of the atmosphere on the Earth's dark side. We determined the height of this layer over the Earth's horizon. We made many, many measurement of the angular distances between various bright stars (Altair, Vega, Sirius, and Deneb), between the Moon and the Earth's horizon, and between Jupiter and the Earth's horizon. We recorded the moment when the stars and planets that we had identified rose and set.

Using the results of these measurements in conjunction with charts and calculators, we determined the element of the spacecraft's orbit and calculated the data necessary for the correction of its trajectory.

During the mission wewworked out a method to assure working solutions to navigational problems by using simple calculators. Such a method can be employed to duplicate and improve the dependability of flight control.

We also did a series of experiments whose aim was to study the design characteristics of the spacecraft. For example, we made measurements of the deformation of the elements of the spacecraft's structure, deformation caused by the effects of the vacuum and the heat of the Sun on one side. There were moments when three times in a row we flew in an orbit which was continuously illuminated by the Sun -- i.e., along the terminator.

We turned the spacecraft and oriented it toward the Sun on various axes. We thereby defined the inertial characteristics of the spacecraft more precisely and determined the moments of inertia and the location of its main axes.

During the mission we studied the working of precision devices /96
and optical assemblies in the environment of space. We evaluated the effect of aerodynamic and gravitational disturbances on the dynamic characteristics and controllability of the spacecraft.
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By using optical devices we determined the precision characteristics of gyroscopic instruments and orientation and stabilization systems.

We continued to examine the nature, the dynamics, and the brightness characteristics of the luminous particles which we saw through the window.

Throughout the mission, we evaluated the condition of the windows of the orbital and command modules and the effect of space upon their optics. Thus we noted that the window of the orbital module, which was toward the Sun for a long period of time, was very hot; while the opposite window at the same time became very cool. A slight moisture condensation (small drops of water) appeared on the latter, but it was easily wiped away with a cloth.

On the mission's fourth day, as many as twenty scratches of 2-3 mm length appeared on the outer glass of the command module's rightside window. They ran along the spacecraft's longitudinal axis.

A day before the end of the mission, we discovered small dust particles, in the shape of a dot with a tail, on the outer glass of the orbital module's windows. The tails were up to 2 mm long.

The minute dust particles and scratches which appeared on the outside of the windows were in our opinion traces of cosmic dust -- micrometeorites.

Neither scratches nor dust prevented us from making observations, measurements, movies, photographs, or doing other operations during the mission.

We also made observations of the light effect which appears as the thrusters and attitude-control engines operated. The operation of the engines against a dark background is accompanied by very weak flashes on the solar battery panels. They have a reddish tint, and give the impression that someone is obliquely shining a very weak red flashlight on the solar batteries. Every /97
time the engines fired, we saw a whole flux of luminescent particles of various sizes.

Throughout the mission we periodically determined what the absolute humidity was in the various areas of the spacecraft's living quarters. We did research on the physical characteristics of the phenomena and processes which take place in space. We studied the passage of radio waves of different frequencies through the Earth's atmosphere. We studied the intensity of cosmic radiation and determined that of continuous solar radiation more precisely.

Throughout the mission we recorded the readings of many instruments. There was always much work to do, therefore, and somehow the time for our next report arrived unnoticed.

On our 87th revolution we answered the questions of specialists who were following our flight. On the 91st revolution, these specialists again asked a great many different questions. Here is how these conversations in space went.

"Falcon, this is Dawn, how do you feel?"

"Dawn, this is Falcon, everything is in order, we feel fine."

"Falcon, is there any dust in the command or orbital modules, on the gratings of the cooling and drying units, or on the filters of the regeneration equipment?"

"Dawn, this is Falcon, there is no dust in the living quarters of the spacecraft, but there is a film of various small fibers on the grates of the cooling and drying unit and on the filter. We vacuum this up every so often."

"Roger, this is Dawn. How many times a day do you use the vacuum cleaner?"

"We use it two to three times per day. We tidy up once or twice during the workday and invariably before going to sleep. It is pleasant to work and rest when it is quite clean, so Vitaliy and I always maintain order and cleanliness on board."

"Roger. What is the status of the transfer indicators on the water condensation containers, first, of the command module and, second, of the orbital module (these were the small tanks into which we pumped the water condensation from the cooling and drying units)?"

"This is Falcon. There still have been no transfer (meaning that the tanks are still not full)." /98

"Falcon, from which container are you now drinking water."

"Still out of the first container. At day's end, to be sure, we will switch to the second container."

"Roger. How much juice are you drinking?"

"We have a lot of juice. We drink it regularly, as needed."

"Roger, Falcon. How visible are the stars through the windows of the command and orbital module at night and during the day?"

"At night all the stars are clearly visible through all windows. During the day, only the brighter stars are visible; they are best seen through the window opposite the Sun."

"Roger, thank you. Do you have enough cloths?"

"Yes, quite enough."

"Falcon, all the specialists here thank you for the thorough answers to their questions. Our communication ends with this, goodbye until our next report."

"Roger, greetings to all, this is Falcon."

We did not have enough time to spend on television and radio transmissions, nor did we succeed in telling about the more minor matters and about our life on the spacecraft. I will try to fill in this gap.

Our every working day in space began over our territory, from the moment our spacecraft entered the radio reception zone of our ground control stations. In the first days of the mission, this came during Earth night; at the end, it came in the morning and afternoon. Our working day thus did not coincide with the working day of those on Earth.

At the time set by the mission program, we woke up to the ringing of the onboard alarm clock. We woke up quickly. After sleeping, we felt light, cheerful, and fresh. Without wasting any time, we quickly washed up.

It hardly seems a matter of principle: to shave or not to shave during the mission? But to see how we grew bristly day after day was to admit that it is not very pleasant. Let alone appear in front of a television camera during a television report to Earth. We would not wish to look like that. It is therefore /99 necessary to shave.

But how? Previously, on the Vostoks, no shaving equipment was provided. But they flew a maximum of 5 days. But how were we to do it? Perhaps by inventing some sort of device. As it turned out, there was not need to. It was possible to get along completely without the usual safety razor. Moreover, a dry cream substitutes well for soap lather.

We also tested a special electric razor which sucked the hairs up through a filter. At the beginning of the mission, Vitaliy and and I shaved with this electric razor, but on the fourth day I, and on the sixth day, Vitaliy, went back to the safety razor, even though shaving with one or the other was equally comfortable. It was simply that it felt better after shaving with a safety razor.

After shaving we washed our faces and hands, worked over our oral cavity and massaged our gums. This we did with cloths moistened with lotion and dry towels.

Usually people take a bath and change their underclothing every week. We could not break this tradition! We took care of the underclothing quite simply: we each took two changes of

linen and two pairs of socks with us. Hygiene specialists had to ponder long and hard over how and with what to replace a bath. Finally, they substituted towels moistened with lotion. On the seventh and fourteenth days of the mission, we rubbed the entire body with moist towels and then dry towels; afterwards we put on fresh clean underclothes and socks. There was a very pleasant sensation afterwards, as if we had actually bathed.

The daily agenda of the mission program specified times to eat -- breakfast, lunch, or supper.

It is fully understandable that on this mission man himself, his vital activity, and his work capacity drew great attention from specialists in space biology and space medicine.

The preparation of our space expedition on Soyuz-9 required answers to a series of absolutely new problems, which the cosmonauts had not encountered previously. They were all basically the result of the long duration of the mission. When its dates were set, it became clear that man will not be fed by sandwiches, meat pies, canned foods, and juices alone for 18 days. Thoughts therefore turned to hot food. In space, the result was hot coffee for breakfast and a hot dish for lunch every day. A food warmer -- a special electric device with a heating coil -- was installed in Soyuz-9 for this purpose. Before eating, we placed aluminum tubes of coffee, cocoa, or soup in it, and there the food was heated to the specified temperature; we ourselves could regulate it as we wished. In a few minutes, the hot food was ready. It was always a treat to eat hot food. /100

During the mission, we were provided with a well-balanced food ration. Canned and natural products made it up.

In consideration of the mission's duration and the great energy expenditure demanded by the crew's physical activities, the following food ration was drawn up: drinks -- coffee, cocoa, and black currant juice; the first course -- borshch, green cabbage soup, and kharcho soup; second course -- canned meat in 100-gram containers (veal, chicken beef tongue, entrecot, ham, pork loin, minced pork with egg, sausage stuffings); pates -- liver and meat; sour cream in tubes with various fruit and berry purees -- apple, prune, black currant, and cranberry; bread -- table bread, Riga and Borodino bread, honey gingerbread; and non-melting chocolate. Sweets, chocolate-covered candies, fruit fudge, prunes with nuts. And of course, the traditional vobla.

For convenience, the food for each day was packed in a single case and a single pouch. On each case and pouch was a number which corresponded to the day of the mission. Food intake was determined by special instructions glued to the inside of the case.

Each of us, while still on Earth before the mission, chose the food he wanted from all those mentioned. We could substitute one product for another, as long as they were similar in chemical composition and calories, to get a different taste.

For example, before the mission, I exchanged all the liver and /101
meat pates for meat dishes. Vitaliy, on the other hand, likes pates very much, and left them in his food ration.

Our tastes coincided in bread. We took only one kind of bread -- ordinary table bread.

According to the daily working-day agenda, we ate four times a day during the mission: breakfast, brunch, dlunch, and supper.

The weight of the average daily ration was about 1460 grams. Protein content was 139 grams, fat 88 grams, carbohydrates 345 grams, and water 853 grams.

Each daily ration had 2803 calories.

Protein made up 20% of the ration, fat 30%, and carbohydrates 50%.

The assimilability of the food in the ration was protein -- 90%, fat -- 97%, carbohydrates -- 96%, and calories -- 95%.

The food menu is given below (see table).

The food tasted good, especially the meat dishes. The borshch, the green cabbage soup, and the kharcho soup had a tangy and pleasing flavor. In the mornings, it was pleasant to drink hot coffee or cocoa. The food ration basically met our needs and helped us retain a high work capacity.

In the first days of the mission, we did not eat all of the day's food. The leftovers we wrapped up and put away in a food storage container. Vitaliy and I reasoned this way: if we feel good at the end of the mission, then we will ask permission to prolong it for a nineteenth and twentieth day. We could then make use of the leftovers. Later, however, our appetite was good, and we ate all that had been allotted. Sometimes we had to restrain our appetite, especially when there were no meat dishes in the supper menu. On the sixteenth day of the mission, we asked mission control center for permission to lengthen the flight to 20 days. But Earth told us that we are to proceed precisely according to plan, i.e., at the end of 18 days, on the 287th orbit, we were to /103
land. After receiving this communication, we at once began to demolish that which we had previously set aside; and in the remaining 2 days, we ate, in addition to that which had been specified, everything that we had stored away.

Days 1, 4, 7, 10, 13, 16	Days 2, 5, 8, 11, 14, 17	Days 3, 6, 9, 12, 15, 18
	BREAKFAST	
Ham	Ham	Sausauge stuffing
Bread	Bread	Bread
Chocolate	Sweets	Sour cream
Coffee with milk	Coffee with milk	Coffee with milk
Black-currant juice	Black-currant juice	Black-currant juice
	BRUNCH	
Veal	Beef tongue	Cocoa with milk
Bread	Bread	Honey gingerbread
Candied rinds	Prunes with nuts	
	LUNCH	
Vobla	Vobla	Vobla
Green cabbage soup	Borshch	Kharcho soup
Chicken	Minced pork	Ham
Beef pate (for Vitaliy)		
Bread	Bread	Bread
Fruit fudge	Cookies	Prunes
Black-currant juice	Black-currant juice	Black-currant juice
	SUPPER	
Cottage cheese	Cottage cheese	Entrecote Meat pate (for Vitaliy) Bread
Honey gingerbread	Candied rinds	Candied rinds
Black-currant juice	Black-currant juice	Black-currant juice

Eating at zero gravity, in contrast to conditions on Earth, has several peculiarities. For example, before breakfast, lunch, and supper at home, we used to cover the table, set out a plate for each one, and put out a knife, fork and spoon for each person, as well as all the other dishes. In Soyuz, it was impossible to make such preparations, had we so wished, because without special devices to set the table, everything would float away. And after all, we had no table.

While eating, we had to fasten everything down under elastic bands on the convenience console and in the hands. In our hands

we held tins of meat and a fork, or a tube of borshch, with bread tucked between our fingers.

Here is another interesting features. It is impossible to talk while you chew. Otherwise, a piece of meat or bread might fly out of your mouth along with the air you breath out; then you would have to catch it with your hands. Or else just suck in strongly and the food, which is floating in the air as if it were alive, will fly directly into your mouth with the air. Then you only have to chew it up and swallow it. It only proves that our popular Earth saying -- "when I eat I am deaf and dumb" -- suits zero gravity conditions best of all.

While eating in the spacecraft, one can be in any position, with feet down or up. For example, I always liked to stand with my feet on the ceiling, whereas Vitaliy sat on the couch with his legs to the floor and secured himself with special straps. Our faces would then be at the same level, and we would look each other in the face, in the eyes, but with our faces turned upside down in relation to each other. Such a position was in no way a hindrance, however, and we got used to it, eating calmly and talking, smiling, and laughing in between. On Earth, this would look strange, but in zero gravity it was an entirely regular affair.

During the mission we were provided with sufficient drinking water and black-currant juice. We drank them as needed. We usually drank 42-45 swallows of water a day; we did not want any more than that. After doing physical exercises, of course, we wanted more. I did not drink much black-currant juice -- 5-10 swallows a day. I do not like it very much. But Vitaliy drank unlimited amounts -- he got great pleasure from it and from pestering me. When he drank it, he always smiled slyly and said, "Such good juice, Andrey, it's bad not to drink it, I tell you, and I won't leave any for you." /104

Water is kept in special containers on board the spacecraft. These containers had a straw, whose one end was fastened to the water container and whose other end had a special mouthpiece with a valve. While drinking water, we took the mouthpiece into our mouths. We opened the valve by pressing on a button, and then we sucked the water out of the container. This looked about like a baby sucking milk out of his bottle.

This design for preserving and using water was called for because of zero gravity. Because there is no gravity in space flight, it is impossible to keep water in open containers. At zero gravity the water is suspended, and it cannot be poured (as on Earth), for example, from a decanter into a glass. It breaks up into separate, large and small drops, which float freely about the cabin. In flight, this is dangerous. The droplets can get on instruments and the contact points of electrical circuits and put

them out of order. They can also get into the crew members' air passages while they are sleeping, and this too can have unpleasant consequences.

Usually, when water is kept for a long time (a day or more) in closed containers at room temperature, it begins to lose its flavor. Microorganisms grow in it. But in the spacecraft, which is pressurized and kept at a temperature of 18-25°, the microorganisms could grow even faster.

Ourwwater on board was ordinary cool water from the Moscow water supply. In order to prevent microorganisms from growing in it, the specialists sterilized the water before pouring it into the containers, this by adding a very small dose of silver ions /105
to the water. This method has long been known. Clergymen used this technique when performing their "miracles" with so-called "holy water."

The flavor of the water depends basically on the mineral salts it contains: potassium, calcium, sodium, magnesium, iron, fluoride, iodine, chlorine. It depends on its trace elements as well.

On the average, a man uses 2-4 liters of fluid a day, depending on the character and intensity of the work he does, the climate, and other factors.

In the human body, water makes up about 65% of the weight. The animal and vegetable world cannot live without water.

Even a small water loss, of about 10 to 20%, from the entire quantity in the body, cannhave serious consequences.

At zero gravity, as I have already said, we had no great thirst, and naturally our consumption of water dropped. The doctors, therefore, fearing that our bodies might become dehydrated, kept a constant watch over our water consumption. When we drank only a little, they urgently advised us to drink more. We of course tried to follow their instructions to the letter.

After the morning's washup and breakfast in space, we did a medical check on each other everyday. When our spacecraft flew over ground command tracking stations, the physiological parameters of our bodies were automatically recorded on Earth via telemetry channels. After our radio communication with Earth, our working day agenda then called for cleaning of the crew's quarters and for doing research and experimental work. Two hours after breakfast, we did a set of physical exercises for about an hour.

We ate brunch at a set time. Then we did dynamic operations, experiments, and other operations. According to the flight

schedule, lunch was to be 3 hours after brunch; then there was a rest period; and, no earlier than 2 hours after lunch, we did physical exercises in turns again for an hour. We measured our /106
pulse rates, respiration rates, and blood pressure before and after exercising. We entered the data in the onboard logbook.

Then again to work. We did joint experiments with Earth on simultaneously photographing (from space and airplanes) geographic and geologic objects on the ground; we monitored atmospheric phenomena, and did biological, medical, and technical experiments and tests.

Before the spacecraft left our territory and entered the so-called "dumb orbits" (when the spacecraft was out of radio range), we once again did a telemetry recording of the physiological functions of the body.

As it received our communications and the data from telemetry records, mission control center, in accord with the carrying out of the mission program, objectively evaluated our condition, the status of the spacecraft's systems, the fulfillment of the flight program so far; and then it regularly sent us radiograms with instructions for doing this or that dynamic operation, for doing experiments and making observations, as well as data on the correction of the "globe" (width, length, period, firing time of the "globe") and other communications. These communications specifically indicated the time to begin joint experiments (with Earth), to perform dynamic operations, and to switch on the control and engine systems. As we did individual operations, several additional methodological instructions also came in.

After leaving our territory (at the end of the working day in space) we once again cleaned the living quarters carefully. We liked to keep our spacecraft spotless and in good order. The cleanliness of our quarters is especially important in space flight. Such a necessity is caused by the fact that all small particles, dirt, crumbs, and dust are suspended and in constant motion when in zero gravity (the movement of the air is caused by the unceasing operation of the fans of the regeneration equipment and cooling and drying units). There is some danger, therefore, that foreign particles might get into the mouth and nasopharynx, especially during sleep. Knowing this, we properly kept things clean.

We ate supper at the time set by the day's agenda. After /107
supper and before going to sleep we again did a medical check: we measured pulse and respiration rates and blood pressure. We checked the functioning of all the spacecraft's onboard systems, the cabin's microclimate, and other data. All this we entered in the logbook -- in a special chart of control parameters.

We made detailed summary notes in the logbooks for the space working day that has just passed.

There were special sleeping bags on the spacecraft so that the crew members of the spacecraft could get normal rest. Before going to sleep, we unrolled them and, using the cords at the ends of the bag, we fastened them to the railing of the orbital module. There is no practical significance in how they are fastened in zero gravity: with the head toward the spacecraft's wall, ceiling or floor. After 18 days of flight, we changed the position of the sleeping bags so that we were more comfortable. We slept well no matter how the bags were positioned.

Before going to sleep, we took off our flight suits, put them in their assigned places, and fastened them down with elastic cords. Otherwise they could have floated about in various directions as we slept, and we would have taken more time to find them. We always covered all the windows and turned off all the lights, so that it was dark in the spacecraft. Then we climbed into our sleeping bags, zipped them up, and settled down to sleep. In zero gravity (before going to sleep), man does not require any special position, nor any special bed or blankets, nor soft pillows under the head. You simply relax and go to sleep. If your arms remain outside the sleeping bag, then they will float in a relaxed and half-bent position in the air directly in front of the face. This hinders sleep, and we usually put our arms inside the sleeping bags.

Once, while sleeping in the spacecraft, it was a little hot, and I did not zip up the sleeping bag. Because of random movements of the arms and legs, and because of turning over during sleep, I fell out of the sleeping bag, and, without waking up, floated freely about the spacecraft. When I woke up in the dark at first I could not understand where I was, and only when I turned on the lights in the cabin did I realize that I had fallen out of the bag while asleep and I had found myself on the ceiling. /108

When we lay down to sleep, we were usually in no hurry to drop off right away. The workday passed by in front of our eyes. We remembered what we had done and seen; we wanted to fix in our memory all our impressions and all the beauty of our planet, as seen from the heights of space. But we tried not to bother each other with our conversations. Each of us indulged in his own private thoughts. I thought of Earth, my friends, my daughter Alena, Valentina, my family and dear ones. However, we understood: it is necessary to get to sleep quickly and get some good rest. We knew that a good sleep was important for the successful completion of our flight objectives.

I always slept well in space. Deep sleep. No less than 7 to 8 hours a day. The pulse rate during sleep slowed to about 43-45 per minute; and the respiration rate to 10 times per minute.

We rarely woke up. Sometimes we had good dreams; they were black and white. Doctors say that there are also dreams in color, but we had none. The medical specialists were interested in dreams in color, and they therefore asked us what kind we had had -- black and white or in color? I repeat: we had only black and white dreams.

We always got enought sleep. After awakening, we felt rested, cheerful, and fresh. We felt an influx of new energy.

In orbital flight, our spacecraft circles the Earth 16 times in 24 hours (an Earth day). During one revolution we had both day and night in the spacecraft, i.e., the spacecraft was on both the Earth's dark and light sides. However, by the time the mission is completed, the days and nights in space can be of various duration. Thus, in our mission, our spacecraft flew along the terminator for about 3 days (from the third to the sixth), and for all these 3 days we were on the Earth's light side. The Sun did not dip below the horizon at all. Then it began to set for several seconds, gradually increasing the time interval between its rising and setting. This was a very interesting /109
phenomenon. In these unusual conditions, we lost our sense of the change of day and night. We gradually got used to thking that the days are purely relative and lived only by the clock. We worked at the specified time, and, when it came time to sleep, we lay down and fell asleep. And then we got up at the specified time.

During the mission we quickly got used to the quiet monotonous sounds of the instruments, the electric motors, the fans, the regeneration equipment, the cooling and drying units, and the onboard clock. We could recognize the characteristic sounds of a command issuing from the timer programmer. We clearly heard the switching on of a selected program, the firing and cutoff of the main engine and thrusters, and the operation of different valves. By listening to these characteristic sounds, we soon could clearly analyze the operation of the spacecraft's various systems. We got used to these sounds to the extent that they did not bother us while we worked and slept.

While in space, we did not get enough of the noises and phenomena that are familiar to man back on Earth. Here we heard noocity or village noises, nor the sounds of the forest and the wind, nor the singing of forest birds. There was no aroma from beautiful flowers, or from the earth, water or the forests. We were neither hot nor cold. We felt no wind or rain, no blizzards or snow.

We genuinely yearned for these familiar sounds, smells, and phenomena of the Earth. Sometimes we felt, heard, and saw them in our dreams.

A strict regime of work and rest was stipulated for the 18 days of the flight program. In many ways, high work capacity and, consequently, the successful performance of flight objectives, depended on how punctually we kept to the schedule and the program.

Therefore, we strictly adhered to the regimen of work, sleep, eating, exercise, and medical checks of ourselves and each other.

Throughout the mission, the doctors every so often asked us a great number of questions. Our answers were brief, but despite this, they gave the specialists additional information on the status of our health, on how we felt, on our work capacity, and other data. /110

Here is how our "medical" conversations went (I quote from the records):

"Falcon, this is Dawn. Do you fall asleep quickly?"

"Dawn, this is Falcon. We fall asleep quickly, and we wake up to the onboard alarm clock at the schedule time."

"How long do you generally sleep?"

"About 8 hours."

"Did you wake up at night and, if so, how many times?"

"Once, because of a cool breeze from the cooling and drying unit."

"How do you feel and work after you have slept?"

"We feel and work well after we have slept."

"Are you thirsty?"

"Not particularly."

"Does your handwriting change from day to day? What sensations do you have while making precise movements during the missions?"

"Our handwriting depends on how comfortably we are secured in the spacecraft, as well as on the position of the hands and the logbook. We do precise movements without difficulty -- easily and unerringly. We did not experience any particular sensations while secured."

"Do you get dizzy while doing your physical exercises? How much do you perspire?"

"There is no dizziness or unpleasant sensation while doing physical exercises, but while doing deep trunk bends forward and down, there is a barely noticeable sensation similar to that which we experienced under the impact of Coriolis acceleration (as during our training sessions). There is little perspiration, it depends on the exertion."

"What do you want -- to increase or decrease physical exercises?"

"We have no particular desire to increase our exercise, but sometimes we do wish to reduce them. We do the full set of exercises."

"How much time is needed to do the set of physical exercises?"

"Forty to fifty minutes, if we donnot count the timewwe need to put up and take down our sports equipment."

"Do you feel thirsty, and are you satisfied after drinking /111
some water?"

"We do not feel thirsty, but we drink the water as needed."

"Do you drink the water with pleasure?"

"Yes, with pleasure. Especially after exercising."

"How much water does each of you use per day on the average?"

"Forty to fifty swallows per day."

"Do you have a sensation of blood rushing to the head after exercising?"

"No, now now."

"What exercises have caused and now cause a Coriolis sensation?"

"Previously, barely noticeable sensations appeared after doing a deep forward trunk bend, but now it is almost not noticeable."

"How many minutes after your physical exercises does your pulse rate return to its original level?"

"It returns quickly, after 10 or 15 seconds."

"What exercises do you prefer to do during your active rest period?"

"None in particular."

"How much juice do you drink during the day?"

"I drink 5-6 swallows, and Vitaliy more."

"What is the condition of your skin where the electrodes are placed?"

"The skin is normal."

During this period of radio communication, our doctors advised us to do the following:

"Drink water until you quench your thirst."

"Drink the water in the command module last (up to then we had drunk from the tank in the command module a few times)."

"Drink more black-currant juice, five to six swallows three times a day."

On the 163rd revolution, our conversation with the doctors was repeated.

"Falcons. On what hooks do you fasten your medical harness with the electrodes?"

"The same as on Earth. We are not yet any thinner." /112

"Do you sleep at non-scheduled times?"

"No, not then. Only at the time specified by the program."

"Do you wake up when sleeping?"

"I have awakened twice. Once because of a cool breeze from the fan of the cooling and drying unit, and again 3 days ago. I woke up and went back to sleep right away."

Vitaliy added something about himself.

"I too have awakened twice. Once a call from the ship Kosmonavt Vladimir Komarov woke me. The second time I woke up at night, and as I usually do, I drank a lot of water."

"Are you doing all the physical exercises scheduled?"

"Yes, we do them all."

"Are you eating up all your daily food ration?"

"We eat all the daily food ration. Yesterday evening at supper we each ate a tin of canned meat too. It was not enough (these tins had been saved from the first days of the mission)."

"Have you fully adapted to weightlessness."

"Yes, we have fully adapted. Neither Vitaliy nor I now has any unpleasant sensations."

"Dawn, this is Falcon 2 (Vitaliy). I have a sensation as if my entire vestibular apparatus had been cut out and thrown away and as if an inertial sensor had been left in its place. This inertia sensor senses a stabilized flight. It also feels the turning of the spacecraft, not as an unpleasant sensation, only as something different somehow. A slightly different mode, that's all. And that's good. Did you read me?"

"Yes, we read you."

On the 193rd revolution, on the twelfth day of the mission, this conversation was again resumed.

"Falcons, do you feel tired? This is Dawn."

"Dawn, this is Falcon. After 12 days, of course we feel tired. Work is work. Our spacecraft has all facilities for normal operations and good rest for the crew members, but, all the same, we feel tired after 12 days." We are carrying out the /113
flight program in full despite this."

"Are you overburdened by the flight program?"

"Basically, the program is made up as normal, but on several revolutions when there are dynamic operations, we get cramped for time and have to run like a squirrel on a wheel."

"How do you use your afternoon rest period?"

"We use it basically to fill out the logbooks. We make entries about our work and our observations."

"How do you do your physical exercises? Have you cut short the time it takes to do them?"

"By comparison with previous days, the time needed for physical exercises has been reduced. Now we do them more rapidly and energetically. This can be explained by the fact that we are completed adjusted to conditions here. We have changed the order in which we do several exercises, so as not to waste time changing

the elastic cords. As we do our set of physical exercises, we exert ourselves about as average. Here is comes much lower than on Earth. In order to get a strain similar to that on Earth, we must do more large muscular (strength) exercises. In general, one can get various exertions here. It depends on us."

"I read you. This is Dawn. Do you need more sleep in comparison with the first days of the mission?"

"No, no more. Seven to eight hours is quite enough to get a good rest."

"How do you evaluate the effect of sleeping on an inclined bed during the prelaunch period on how you feel in zero gravity?"

"We evaluated it positively. It seems to us that this helped us adapt toweightlessness to a certain degree."

"How do you evaluate your food ration?"

"Basically, it is enough, but when we work a great deal, it does not seem quite enough. Sometimes we have additionally eaten some meat or something sweet from the stores we had set aside.?

"Have you drunk all the water from the second container?" /114

"No, not yet. When we finish it, we will report it."

"We have received your answers. Thank you. Our communication comes to an end with this. This is Dawn."

"Roger, this is Falcon."

* * *

Thus, the doctors did not neglect us during the mission.

They could be satisfied. We continued to feel well all the time. The spacecraft's life-support system functioned normally. It constantly maintained the proper conditions of the spacecraft's "microclimate" -- atmospheric composition, temperature, humidity, and atmospheric pressure -- the conditions to which we cosmonauts were accustomed. The atmospheric pressure was between 760-790 mm mercy, the air temperature between 19-26°C, the relative humidity between 60-70%, the partial oxygen pressure 160-260 mm mercury, and that of carbon dioxide did not exceed 10 mm mercury even when we are doing our physical exercises.

Telemetry sensors were placed in the various systems of Soyuz-9 to measure the partial oxygen and carbon dioxide pressure, temperature, humidity, and air pressure in the life-support

and heat regulation systems in the spacecraft's crew quarters. They recorded whether individual fittings, valves, systems are operating correctly, and they record fuel parameters and the spacecraft's angular velocity. The crew members regularly use special sensors to measure their pulse rate, pressure, respiration rate and many other physical and physiological parameters. All the readings of the sensors were recorded on tape.

Before the spacecraft enters the radio-reception range of a ground mission control point, the giant conical dishes of the ground antennas (for the reception of telemetry radio signals coming from the spacecraft) aim toward the point on the horizon where the spacecraft will appear. As soon as it comes within range of the antennas of ground stations or the ships, an inquiry from Earth begins the sending of information. The radio signals and telemetry data received go into electronic computers, where /115 they are processed.

The computers do a logical analysis of the condition of the crew. These data the computer gives on a numerical printout.

The manned spacecraft control center, as it analyzes these data, always has a concrete picture of the condition of the crew (and also the systems of the spacecraft as a whole) and accordingly can render help at any time to the crew. It can also, basing its judgment on the conditions and circumstances and on how the crew feels, decide whether to continue or abort the mission.

Earlier brief space flights have shown that in zero gravity the human body undergoes rather significant changes. This concerns primarily the cardiovascular and muscular systems, as well as the bony tissues.

As the human body evolved over many centuries, it adapted to the conditions of life on Earth; that is, it developed in itself those attributes needed to overcome the Earth's force of gravity. It developed a strong skeleton, a strong muscular system, and a reliable blood circulation system which provided a supply of food to the cells of various organs whatever their spatial position; in all this, the entire system reacted clearly to any change in the body's position.

Weightlessness is a phenomenon that is entirely new and unfamiliar to the human body. Nevertheless, a person who goes through a special training program adjusts relatively quickly to these new conditions. However, several rather substantial changes take place in the human body while doing so.

During the mission, we did a considerable number of medical and biological experiments and tests to study further the functional condition of the cardiovascular, motor, and a number of analyzer systems -- the motor, the vestibular, the visual, the proprioceptive (muscle-joint sensations), and others.

Great attention is given to the study of the vegetative reactions on nearly all space missions, both Soviet and American. B.V. Yegorov, who is both a cosmonaut and a physician, noted the lowering of both the maximum and minimum blood pressure in all /116
crew members of the Voskhod spacecraft. A change in the pulse rate and blood pressure was noted in American astronauts who flew on the Apollo missions. Gordon Cooper, after a 33-hour flight, had a steady reduction of blood pressure and a syndrome of arteriostatic instability. The Soviet cosmonauts who flew on the Soyuz missions had some increase in both the maximum and minimum blood pressure at rest and after doing measured physical exercise.

In the prolonged missions of the future, great and intense work awaits the cosmonauts.

We know already now what tremendous and fruitful work the crews of the Soviet orbital station Salyut and the American Skylab did while in space. But then, in 1970, our notion of what effects prolonged weightlessness would have on the cosmonaut's work capacity was still rather vague and mysterious. We had to "find the key" to the solution of the problem.

With this goal in mind, we studied the reactions of the cardiovascular system and respiration to measured physical exercise which simulated the performance of various working operations. The measured physical exercise used for this purpose was a functional test with an expander, which we stretched out with a force of 10 kg thirty times per minute or we pumped out moisture condensation by hand at a rate of twenty strokes per 2 minutes. Afterwards, we measured blood pressure, and we counted the pulse and respiration rates both before and after the tests (2 minutes and 15 to 20 seconds after).

At the beginning of the mission, in conditions of relative calm, the pulse and respiration rates and the blood pressure did not change substantially. Only on the fourteenth day can one notice a tendency toward some increase in the pulse rate and maximum pressure. After doing measured physical exercise, a more significant (than on Earth) increase in blood pressure and pulse rate was noted. However, 2 minutes after doing the test, nearly all indices returned to their original level.

A small increase in the ventilation of the lungs in compari- /117
son with prelaunch indices was also noted. Two minutes after finishing the measured physical exercise, it returned to its original levels.

In analyzing the samples of the air we breathed out, a more pronounced absorption of oxygen and a heightened discharge of carbon dioxide was observed. The same regularity was noted after

doing tests with measured physical exercise: the momentary consumption of oxygen and discharge of carbon dioxide exceeded the original data.

A calculation of energy expenditures is needed in order to know the average amounts of oxygen consumption and carbon dioxide discharge. By using these data, the amount of oxygen needed in the spacecraft's life-support system can be determined. Calculations showed that the energy expenditure during flight, as compared with prelaunch data while at rest and while doing measured physical exercise, at first increased; but toward the end of the mission a slight reduction of gas exchange processes and a reduced energy expenditure were noted. The pulse and respiration rates at rest and after exercise differed little from the data from the prelaunch period.

It was of great theoretical and practical interest to test proprioceptive sensitivity (muscle and joint sensations). This sensitivity was determined by a simple and well-known instrument -- a dynamograph -- which was used to ascertain how accurately a specific muscular exertion can be sustained with open and closed eyes, and before and after measured physical exercise. The exertion was created by pressing the thumb on the dynamograph's spring mechanism while the left hand firmly holds the dynamograph. The force applied was determined visually, by looking at a dial. The problem was to sustain a force of 600 grams for 10 seconds. During prelaunch training we developed a consistent ability to sustain a muscular force of 600 grams without looking at the dial (the ability was considered consistent with a deviation of plus or minus 10 grams).

We also studied proprioceptive sensitivity while sustaining a muscular force of 20 kg (consistency: plus or minus 1 kg). /118
This was done with a hand dynamometer.

The maximum muscular force of the hand was also determined at different times of the day; this was a single maximum squeeze of the hand dynamometer by the right and the left hands.

While sustaining the assigned muscular force of 600 grams with open and closed yes, our accuracy was within minus 10 and plus 70 grams, most often on the plus side. The maximum deviation -- 70 grams -- was on the 16th day of the mission. At the beginning of the mission, the deviation was significantly less. In all probability, this is explained by the retention of skill gained on Earth. Measured physical exercise had no essential effect on sustaining a muscular force.

While sustaining a muscular force of 20 kg, there was a noticeable increase in the size of the errors in comparison to prelaunch data. The greatest deviation was plus or minus 5 kg,

most often on the plus side. Evidently, this is explained by the fact that on Earth the energy expenditure needed to do static and dynamic work (pressure on a dynamometer) is controlled on the basis of a strictly determined overall stimulus of the muscle-joint sense. In zero gravity, no force is needed to do the static operation of holding the arm in a given position, but, as a result of previous experience, this force is preserved as before. Therefore, part of the energy which previously was needed to do static work is now expended on dynamic work.

The maximum muscular force of our hands decreased during the mission on an average of 10 kg.

Vision is one of the main channels by which information about our surroundings enters the brain. The eyes are very delicate and sensitivie organs. Naturally, our medical specialists wanted to find out as much as possible about the working of the sight organs during a prolonged mission in space.

The goal was to study the peculiarities of visual perception /119
in space, where the usual Earth atmosphere is lacking. Can the organs of sight preserve their work capacity over a long period of time, can they retain their accuracy in discerning light contrasts on various surfaces.

With this aim in mind, a series of experiments to study visual acuity, work capacity, and contrast sensitivity was completed. Instruments, various devices, and contrast sensitivity measures and charts were used to do these tests.

These tests were done several times during the mission using only the ordinary light of the orbital module.

The results of the tests did not differ essentially from the data from previous missions. This confirms that the basic function of the visual analyzer did not worsen even on missions of 18 days.

The experience of the Soviet and American cosmonauts has shown that several deviations of the vestibular apparatus in zero gravity are a serious problem. Those who have a weak vestibular apparatus sometimes have illusory sensations about the spatial position of the body; or else vegetative malfunctions occur in the form of the initial stage of motion sickness and discomfort. Simply speaking, one feels about as if he were in a rolling sea and having unpleasant sensations. The preservation of high work capacity and vital activity on the part of the crew depends a great deal on the normal functioning of the vestibular apparatus.

A leading role in defining the main spatial coordinates (horizontal and vertical) belongs to the visual and vestibular

analyzers. The given spatial coordinates on a space mission, where there is no customary "up" or "down," are the axes of the spacecraft, in relation to which a judgment is made about the accuracy of determining the vertical and horizontal planes.

In order to study spatial orientation, a conical-shaped tube was used. Inside it had a rotating disc with a slot in it. A /120
battery-powered light source was placed behind the slot. The disc could be controlled by using a remote-control handle, a thumbscrew on the handel was mechanically linked to the disc; and there was a separate control handle for operating with the postural (body) vertical and horizontal.

The testing was done in different planes of the spacecraft, both in stabilized flight and while turning. The device was placed on the head and fastened at the level of the eyes. A cassette was set up. The light source behind the slot was turned on, and we, in turn, using the remote-control thumbscrew stopped the slot in a vertical and horizontal position several times and locked it in position with a trigger. Then the light was turned off, a new cassette was loaded, and the test continued without the light source.

Unfortunately, the experiment was done only a few times. It is therefore premature to draw conclusions. However, the results we received, with minor deviations from the control data, confirm that we retained our spatial orientation during the mission and that we had no spatial illusions.

During the missions we also used a special graduated needle to study changes in sensitivity to pain. A micrometer screw measured out how far the needle protruded; and the needle was applied to the back of the hand. The smallest projection of the needle the subject perceived as a prick was the pain threshold.

The results of the experiment indicated a tendency for the pain threshold to be lowered during a prolonged mission.

To work in space it is necessary not only to keep feeling well and to maintain sufficient muscular power, but also to possess the required reactions.

One of the important questions, the answer to which specialists and cosmonauts have been waiting, is what to entrust to man and what to entrust to automatic machines. This is not a theoretical but a wholly practical question.

The answer to it will be obtained neither on Earth nor in /121
ordinary circumstances.

It is necessary first to know what man can do in space, to know how accurate and coordinated his movements will be in zero

gravity, to know his reaction time to simple and complex signals. We were therefore to do a whole series of experiments in this regard. One was on a special instrument: one had to use a control lever to "trace", i.e., follow the path of, a signal as it moged about a screen. The signals were of various kinds -- predictable (which moved regularly along a curve, say, a sine curve) and unpredictable, random. The former were of course simpler to trace.

Tests of the reactions to such signals allowed specialists to determine the extent of the "transmissive functions" of man as a basic link in the control system. It also allowed them during the next stages of the mission to establish changes in the coordination of motor activity and in the accuracy of reactions as we adapted to space.

Work capacity was evaluated also by other means. For example, our activities while doing various manual control operations of the spacecraft were checked on a special analog device, which simulated the various dynamic modes of control. But, it seems that I am already deep into a highly specialized field, and it is therefore time to interrupt these discussions, the more so because the time for our next communication, our next television report, is drawing closer.

"Good evening, dear viewers! We are continuing our television reports."

"Today we will tell you about our medical monitoring."

"You now see a medical harness on your television screens. We put it on ourselves. At certain points of the body we place medical electrodes, which are built into this harness. So as to have better contact between the skin and the electrodes, we dab on a special paste and do a preliminary treatment of the skin. You are now watching as Vitaliy prepares the medical electrodes for operation and smears them with the special paste.

"All the electrodes lead out to a special connection, which /122
is plugged into the spacecraft's onboard system. Our physiological parameters are transmitted via telemetry channels to mission control stations on the ground. The medical specialists know from these data the health of the crew members. We are always under medical observation.

"In addition to the medical harness, there is a tonometer on the spacecraft. We use it every morning and evening and before and after exercising, to take our maximum and minimum blood pressure. We also count the pulse and respiration rate. Every day we thus do medical checks on ourselves and on each other. All data about our health we report to central mission control.

"Now you are watching Vitaliy take his blood pressure. The dial of the instrument shows on your screens. It reads 120 mm of mercury; this is the maximum pressure. And the minimum is 70 mm of mercury. Vitaliy's blood pressure is excellent. Even on Earth he had almost exactly the same figures. Vitaliy, tell us please, what is your present pulse rate?"

"Sixty-five."

"Yes, his pulse is always 60-65 beats per minute. Mine is now a little higher, about 70-74 per minute. This to be sure is from the excitement of doing this television report. Yes, the lights are on here, and they create a strong warm current.

"In general our health has been good and we have felt good during the mission. We have no complaints about our health. Vitaliy is saying that his appetite is excellent. Our food is good. The water is good, cool Moscow water, as at home, when you drink cold water from the tap.

"Comrade, television viewers, our television report has come to an end. We are signing off with this today. In our next meeting we will try to acquaint you with the other characteristic moments of our working day, our existence, life and work on Soyuz-9. Goodbye. Until our next meeting."

* * *

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I now wish to return to our conversation about the effect of weightlessness on man, but to approach it from a slightly different angle.

In zero gravity, in conditions different from those on Earth, the human body begins at once to react to it, to adapt to these new conditions. Here is a concrete example. The cardiovascular system reacts quite distincly to the body's position. When a man is in a vertical position (standing or sitting), the muscles of his legs begin to contract with great frequency and with little amplitude in response to the signals coming from his regulatory mechanism. They force the blood out of the lower extremities and thereby improve the body's blood circulation; thus they give no small help to the heart and its work.

In zero gravity, as a result of the fact that the blood, like the entire body itself, has no weight, this purely reflex contraction of the leg muscles lowers blood levels in the vessels of the lower extremities and increases the flow of blood to the heart and head. Therefore, at the very beginning of the mission, a certain puffiness of the face appears, as well as a feeling of heaviness in the head. The body's regulatory systems sense the rush of blood to the heart as the presence of superfluous fluid

in the body, and they begin to expel it -- though it is not superfluous at all -- through the kidneys. The volume of circulating blood decreases.

Yet another example.

In zero gravity, the extensors of the legs and trunk (the antigravity musculature) do not essentially perform the functions they do in conditions of Earth gravity. They almost cease working, and, as a result, the phenomena medical specialists call "atrophy from inactivity" are observed, i.e., the same thing is seen among people who are forced to spend a long time in bed, as a result of which their leg muscles atrophy. Toward the end of our mission, the size of our thighs and shins decreased.

In the second half of the mission, I looked at Vitaliy's legs one day: "Look, your legs have become quite thin, like matchsticks; they weren't like that before." He looked at my legs and replied, "Look at your own, they are also thinner."

Muscle tone in the lower extremities, in contrast to that of /124
the arms, was lowered. The strength of the hands was almost unchanged, but our orthostatic strength, which depends on the muscles of the spine and legs, was reduced noticeably.

As is well-known, the signals which have to do with the body's spatial position are linked primarily to the work of three analyzers -- the visual, the vestibular, and the motor. Those parts of the analyzers which perceive are the receptors.

When we use these receptors on Earth, we determine where we are. For example, when we stand up, the receptors on the feet and leg joints signal the central nervous system about the body's position. These signals, together with those of the vestibular and visual analyzers, are sent to the brain.

The brain analyzes incoming signals and easily and precisely determines its position in space.

The sense receptors in the muscles, the skin, the joints, and the vestibular apparatus are adapted to work in the conditions of Earth gravity, i.e., with a clear interaction with a support. But there are no such conditions in zero gravity for their normal working, and they therefore turn out to be superfluous, unnecessary for determining one's position in space. Moreover, they can send false signals to the brain.

We can determine our position in space by using only our sight. In zero gravity, therefore, new coordinating links were developed in the central nervous systems, and a new order of /125
interaction among the analyzing systems was established.

In zero gravity, the pulse rate stays at a relatively constant level, six to ten counts less than on Earth. This happens because the blood has no weight, the need for muscular exertion diminishes, and the stimulation of the central nervous system (which regulates the work of the cardiovascular system) undergoes certain changes. The work of the heart in zero gravity is always easier than on Earth; as a result, its muscles also lose their tone. However, the human body is extraordinarily flexible, and it adapts to very different conditions. Gradually, it becomes accustomed to zero gravity.

In zero gravity, the functioning of the physiological sensors on the cosmonaut's body produces several difficulties. Electrodes constantly attached to the body can lead to the appearance of unpleasant sensations and inflammation of the skin where the electrodes are placed.

At the beginning of space flight, when we flew the Vostok spacecraft, the physiological sensors were placed on the cosmonaut's body throughout the mission, i.e., they were attached before the mission and taken off only after the mission was over. Yuriy Alekseyevich Gagarin flew 108 minutes. Gherman Stepanovich Titov flew 24 hours. They experienced no discomfort in this respect.

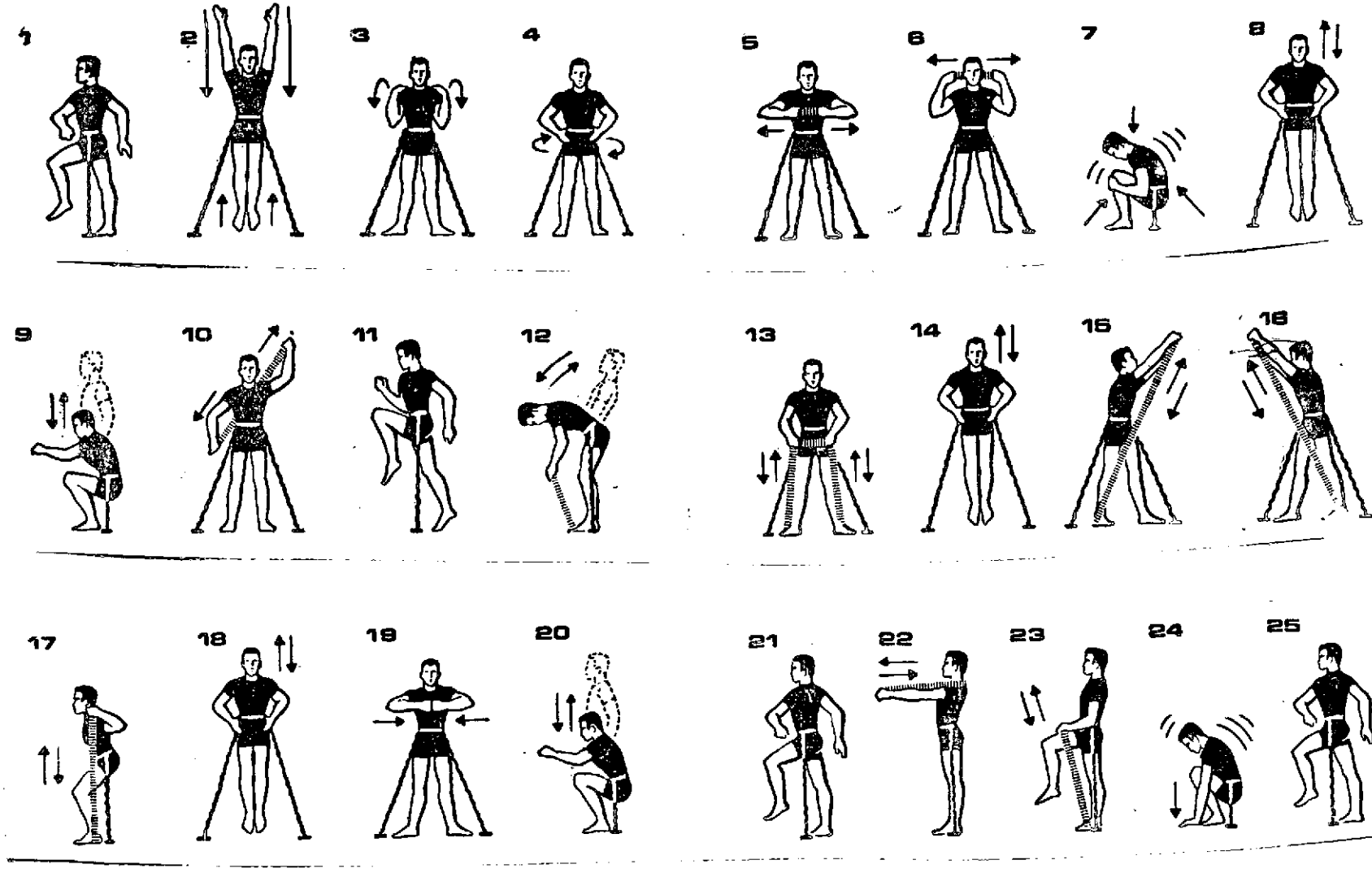
After carrying out a 4-day mission on Vostok-3, I (as well as the other cosmonauts who flew after I did) had irritated skin where the sensors had been placed.

The specialists designed a new removable medical harness /126
with all physiological sensors built in with elastic straps. In those places on the harness where the sensors were installed, special slots were made so that they could be shift periodically; the purpose of this was to change the places where they attached to the body.

These medical harnesses are easily put on and taken off. They are comfortable to use. They do not cause irritation or inflammation.

In order to record our physiological indices before the launch of Soyuz-9, we donned the medical harnesses and did not take them off during the first and last three days of the mission. We periodically moved the sensors about, i.e., along the slots, in order to let the skin return to normal. Throughout the rest of the mission, we donned the harnesses twice a day, whenever physiological data were to be recorded and transmitted to Earth.

At a time specified by the mission program, we were to record our physical indices. We put on the medical harnesses, buckled ourselves in our working chairs, and then plugged the harness into the onboard medical monitor and telemetry system apparatus.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We took these recordings once a day while at relative ease and again while we were doing measured physical exercise tests. Specialists on Earth monitored how well we did this exercise visually, via the television channel.

We recorded and sent back to Earth (via telemetry channels) the following physiological indices: electrocardiogram, seismocardiogram, pneumocardiogram, and pulse and respiration rates. These data went to the measuring stations at the command-tracking center, where specialists processed them and passed them on to the medical monitoring group in the mission control center. /127

Every day during the mission, we filled out a chart, in which the following medical data were entered: headaches, pains in various places, colds, dizziness, nausea, dryness of nasal and oral mucous membranes, eye irritation, physiological deviations, sleep, pulse rate, blood pressure, and general health. Fortunately, we were normal throughout the flight, and we had to fill out the last six columns only.

On Earth, the medical specialists, who had such a rich store of medical and monitoring information, which allows them to discover the physiological mechanisms of the human body's adaptation to space flight factors, could predict with high probability the state of our health and then make recommendations to the mission director on whether to continue the mission.

A special radiation security staff kept continuous watch over radiation conditions during manned space flights and predicted these conditions throughout the mission. This group uses the results of observations by astrophysical stations, the measurements of geophysical observatories, data on cosmic radiation in space from Earth satellites, and also working dosimetric monitring on board the spacecraft using the readings of instruments, which scientists on Earth receive through telemetry channels. /128

Our mission took place while radiation conditions were favorable. Although there were solar flares during the mission, they did not bring about any substantial changes in the radiation environment in orbit. The Soyuz-9 orbit passed below the Earth's radiation zones, and their radiation had practically no effect on the crew. But the geomagnetic field definitely prevented charged particles from penetrating to the zones through which the spacecraft's orbit passed.

The cumulative radiation dose was considerably less than allowable. It was less than a patient gets while having his thorax or stomach X-rayed.

We had a special medicine chest on board the spacecraft to render aid in case of need. It included tonics, painkillers,

anti-radiation, stomach-intestine, anti-allergic, antibacterial, and antinausea aids, as well as other means of giving first aid. Several medicinal preparations were kept in special syringe tubes.

We felt good throughout the mission, we were not ill, and not once did we have to resort to any medicinal preparations.

To be sure, Vitaliy had a small inflammation near the left nostril and a slightly stuffed-up nose in the middle of the mission.

That day he took three sun baths (he warmed that part of the /129
nose next to the sunward window of the orbital module). This procedure helped him. The next day he was normal again, and thus even here we did without medical preparations.

One of the serious problems of prolonged space flight on spacecraft of the Vostok, Voskhod and Soyuz types is that their crews are forced to lead lives of little mobility. The Americans were in the same situation in their Gemini and Apollo spacecraft. Past missions and tests on Earth had shown that hypokinesia, or muscular inactivity, affected one's condition unfavorable. Changes begin to occur in the working of the cardiovascular system, in metabolism, and in the muscles and bony tissues.

The muscles make up about 40% of the body's mass. But they are not a self-contained entity. All the internal organs are linked to them in some degree. The muscles directly or indirectly influence blood circulation, respiration, digestion, metabolism, and the production of hormones. Their activities condition the central nervous system. Thus, the body is by no means indifferent to whether the muscles are active or inactive.

In conditions on Earth, reduced muscular activity is the cause of many cardiovascular illnesses, including such severe and dangerous ones as arteriosclerosis and myocardial infarction. It is therefore expected that continued muscular inactivity will /130
sooner or later make itself felt in space also.

But we did not intend, as they say, to sit with our arms folded. As we investigated the effect of weightlessness during the mission, we also di experiments to prevent the unwanted effects of weightlessness.

To maintain normal motor activity and muscle tone during the mission, we did special physical training. A set of physical exercises was developed: for speed and strength (first day), for muscular endurance (second day), and for overall conditioning (third day). We did various exercises to maintain the general body tone as well. During each training session, the strain was distributed about evenly to all muscle groups. A considerable place in this training was devoted to exercises such as: slow

and rapid walking, in which the heels strike "the ground." By doing this, we basically trained coordination skills and reproduced inertial-impact action along the body's long axis.

Personal training suits were made up so that we could do our exercises. Elastic components built into the fabric helped distribute the body's muscular exertion equally. We also had a set of elastic cords with loops on the end, so that they could be fastened to the spacecraft's fittings and to the cosmonauts' suits. A special folding floor was built into the floor of the orbital module.

Before doing our physical training, we put on sports outfits and the load suits. We set out the folding floor, fastened one end of the elastic cords to attachments in the command module, stretched them through the hatch into the orbital module, attached their free ends to the suits, thus overcoming a weight of about 10 kg. In this way, the cords pulled us down toward the folding floor and locked us in a vertical position. We then began doing the exercises shown in the diagrams.

We did the physical exercises with great enjoyment. We afterwards noted the "muscular satisfaction" effect and received a charge of energy for the whole working day.

Sometimes we wanted to increase the load slightly and we /131
therefore added two new exercises to the program -- push-ups and one-legged squats.

After finishing the training session, we took off our suits, rubbed our bodies with moist towels, changed clothes, and put away all our sports equipment.

The medical safety team watched us closely, whenever we were within television reception range, to make sure we did all our exercises.

The pulse rate increased to 90-100 per minute as we did our exercises. When we did the same exercises on Earth, the pulse rate reached 120-130 per minute. Our blood pressure did not differ practically from what it had been on Earth.

The system of weighted physical exercises and the concentration with which we did them kept our muscles in "working" condition. However, to get a bit ahead, I should say that the limited size of Soyuz-9 was nonetheless all too evident. After returning from the mission, we needed a rather long time to readapt fully, i.e., to readjust to the Earth's gravity.

Every day we completed in full the designated program of the mission. June 8 approached, my daughter Alena's birthday.

The closer this day came, the more I thought how and in what form to congratulate her and Valentina. I knew that Alena, Valentina, and their grandmothers were watching our television reports every day along with all the television viewers. It had to think of something, some way to send my best wishes. Before going to sleep on the night of June 7, I decided to share my thoughts with Vitaliy. He and I discussed it all thoroughly and decided that it would be best to congratulate Alena and Valentina during our television report and address myself directly to them. Then we decided to show them our souvenir gifts on television. In Shot /132
Rustavel's tiny book Vityaz' v tigrovoy shkure [Heron in a Tiger's Skin], I wrote "To Alena from Papa on her birthday. Best wishes for happiness. On board the Soyuz-9 spacecraft. June 8, 1970." For Valentina, I wrote an inscription in memory of this day in the little book of Russian and Soviet authors (Poemy, ballady, stikhi, pesni [Poems, Ballads and Song]): "Dear Mama Valya on Alenka's birthday. June 8, 1970. Best wishes. On board Soyuz-9. Papa Andrian."

Vitaliy wrote his best wishes to Alena on a postcard with a picture of Lake Baykal on it. Now we were ready for June 8, and we calmly lay down and went to sleep.

After our "night's" rest, Vitaliy and I were in a fine and festive mood. We shaved carefully and began to get ready for the next, this "special" television report. On the 114th revolution, when we got within television reception range, we reported to Earth that we were ready to begin the report. But instead of Dawn, we unexpectedly hear the excited by clear voice of Valentina:

"Andrey, dear, good evening. Do you hear us?"

"Good evening, Valya, I hear you fine."

"We see you, we hear you, we are very excited and very glad. We give you and Vitaliy a hug, and we kiss you both."

"Thank you, Valya. I send my heartfelt congratulations on Alenka's birthday. Say hello to Alenka. Vitaliy Ivanovich and I have some little gifts prepared for you."

"Wait a minute, wait."

Here is Alena's voice.

"Papa, dear, hello."

"Hello, Alena! Hello, Alena! Happy birthday" (I hear her sobbing quietly in my earphones).

"She's getting quiet now" (this is Valya).

"Alena, Uncle Vitaliy and I have some presents for you. Here is a little book, see, and I've written in it: "To Alena from Papa on her birthday."

"Alena, behave yourself and obey mama and your grandmothers. I have had you doll with me all the time. You see, she's floating as if she were alive. Alena, I promise that next time I won't go away on a mission and that I'll celebrate your birthday with you." /133

"Very good. Thank you, papa."

Valentina: "Andrey, I have a message for Vitaliy Ivanovich."

"Vitaliy, do you hear me? Greetings from your family, everything is all right at home, all are well, and they give you a big hug."

Vitaliy: "Thank you very much, thank you, Valentina."

Valentina: "We wish you both success. We'll be waiting, no, we can't wait, to see you back on Earth. (Look at the doll, Alena, see how it floats). Andrey, Alena is quiet now, she will talk with you now."

"Thank you, Valya."

"Daddy, dear, my uncle cosmonauts gave me a turtle."

"A turtle? That's good. Did you say thank you?"

"I said it, I didn't forget. Today we went to see some bees."

"To an apiary. That's good!"

"A bee bit uncle Lesha Leonov. His eye swelled up. Mommy and I went to pick berries, and we picked a lot."

"Well, great. Alena, do you hear me?"

"Yes, I hear you."

"Alenka, I'll come back soon. Don't be sad."

"Papa, why didn't you take me with you? You have such a big ship."

"Next time I'll take you, Alena."

"Really?"

"Yes, really, Alena. Did mama bake pirogi today?"

"No, papa."

"No? Well..."

"My uncle cosmonauts gave me a cake."

"A cake? Bravo! But next time we two will bake pirogi with you."

"I hug you and kiss you both."

"Thank you, Alena, we hug and kiss you, too."

"Papa and Uncle Vitaliy, we'll be waiting for you back on Earth." /134

Vitaliy wants to say something.

"Alenka, Alenka!"

"Yes."

"This is Uncle Vitaliy. Happy birthday, we made a souvenir for you, a postcard. Here you see it, do you see it?"

"Thank you, Uncle Vitaliy, I see it! Where are my roses?"

"They wilted, Alena."

"The roses wilted already, we put them away in a container" (I added).

"Good, Daddy, bring them back to Earth."

Vitaliy:

"We will bring them, Alena."

"Thank you, Uncle Vitaliy."

"You're welcome."

"We have been watching you for the second day already. It was a great temptation to talk with you, but we wanted to surprise you and for Alena to talk with you on her birthday."

"Thank you, Valya. This is really a great surprise."

Vitaliy:

"Thank you, Valentina."

"We are waiting for you on Earth at Star City; all the people of Star City are waiting for you."

"As soon as we carry out our assignment in full, we will without fail come back to Star city."

"Very good."

"Papa, when are you flying back?"

"Soon, Alena, soon. As soon as we finish our job."

"Don't go without me anymore!"

"No, Alena, I'll never fly away again without you."

Valentina:

"Vitaliy Ivanovich, everything is all right at home. Don't worry, you family is watching television and waiting for you back on Earth."

"Thank you very much, Valya."

"Andrey, dear, a big hello from all the people in Star City and to Vitaliy Ivanovich, too. We're waiting impatiently, fly back soon."

Vitaliy:

"Valentina, give my greetings to everyone."

"Of course, Vitaliy. Andrey, we give you a big hug and a kiss. Good luch, until we meet again on Earth." /135

"Till we meet again, goodbye."

Alenka:

"Papa."

"Yes, Alena, I hear you."

"Papa, did you fly over Africa?"

"Yes."

"Did you see Barmaley?"

"I didn't see Barmaley, there are no Barmaleys there."

"Papa, look good when you fly over Africa."

"Good, good, I'll look. We often fly over Africa."

Valentina:

"We read a book, and now she's interested in whether you have seen Barmaley."

"We fly, we often fly over Africa, only we didn't see Barmaley. We'll look more closely now."

"Papa, goodbye."

"Goodbye, Alena, goodbye."

"We flew to the control center to see and talk with you."

"Well done, thank you for doing it, thank you, Alena. Do you hear me?"

"Yes, I hear you, papa."

"Say hello to your grandmothers for me."

"All right, I will, papa."

"Falcons, goodbye. Until we meet again on Earth."

"Goodbye, Valya! Wait for us, Alenka!"

Our exchange ended with this. We left the zone of radio communication.

Talking with my family and dear ones was a real surprise to me and a fine present on Alena's birthday. I felt an influx of energy and good cheer. I felt as if I had been at home, right beside Alena and Valentina. Eight days in the mission had passed, but it was as if we had not been flying, as if there had been no longer separation.

After being thus "recharged," the work in space went well and happily.

* * *

A large part of our program of scientific experiments was devoted to direct observations from space. During the mission, we did and transmitted back to Earth about 20 important "weather /136

reports." For example, on June 3 at 5:27 Moscow time, we recorded a tropical cyclone over the Indian Ocean; and another cyclone over the Bay of Bengal on June 5 at 2:13. One the same day at 6:05, we observed strong thunderstorms over the Great Lakes region of the USA.

We often saw stormy weather and developing and diminishing cyclones over various regions of the globe. As we flew over Kazakhstan and Western Siberia, on the 253rd revolution, we noticed an increase in cloud cover and the formation of a cyclone near Novosibirsk.

We observed stormy and calm surfaces of the seas and oceans and the bands made by the surf in a storm. Storm waves are distinguished from waves in a calm by the large white crests of whitecaps. On the windward side of islands, there is white along the shore, and on the lee side, there are no whitecaps beating on the shore. By observing these features, one can determine the direction the waves are moving. When the Sun is close to the Earth's horizon, the waves show up more distinctly. When the Sun is close to the Earth's horizon, the waves show up more distinctly. The points where clear blue-green sea and ocean water meet the murky greyish-yellow (and sometimes red-brown) discharge waters from rivers can be seen. The shallows over banks and the continental shelf are clearly visible. In lakes with clear water, the bottom can be seen. One such lake is the Issyk-Kul in Central Asia. The submarine channels of the eastern coast of South America, especially near the Amazon, are easily discerned. We could see well enough to ascertain the condition of full, receding, and dried-up rivers, lakes, and inland reservoirs. Small rivers have a yellow-grea color; the deeper ones have a bluish cast. On some rivers, dams are clearly visible. The Aswan Dam on the Nile River in Egypt is quite visible.

On the surface of the Atlantic Ocean near Newfoundland, we noticed many icebergs -- as bright white dots. We could tell which directions ships were moving from their wake. /137

Islands have very different shapes. They are usually surrounded by a beautiful emerald belt. There are mountains and volcanoes on some. For example, as we flew over the Atlantic, we noticed a group of islands, one of which had a volcano. It looked like a circus arena. On its rim, it was covered with snow; in the middle was a round black spot with no snow on it. Indeed, the active volcano still glimmers a bit.

Lake Baykal looks beautiful from space. It is surrounded by the green taiga and on the northeast and southeast by the snowy summits of mountains. The lake's color is dark blue, sometimes a dark green. Saline lakes, by contrast to Baykal, look light or blue-green. As we flew over Baykal, we made a direct report to Earth. Here is its text:

"We are now approaching Baykal. All around is solid taiga; nearby we see snowy mountain summits. There is almost no cloudiness, about one or two units. In front of us we see Baykal, still in the mist, now it is brightening. We will be looking through the window opposite the Sun. The Moon is right on the spacecraft's flight path. Now we are passing directly over Baykal. Here, on its southwest part, the mountain tops are covered with snow. To the south, there is a very beautiful bay with a cape jutting out into it. Not far from this bay is a very pretty island. How charming! Baykal is beautiful yet somehow severe. Now the Sun is low over the horizon, the shadows are longer, and there is more contrast on the surface. There is another large and beautiful island. North of Baykal, just north, about 500 km, something is burning in the forest. It has three sources. There is considerable smoke, which extends for about 20 to 25 km. There is a small fourth source. Just now we are flying over them."

"I read you Falcon. This is Dawn." Earth interrupts our report. "We're making you honorary firemen."

"Good, we accept! But meanwhile we will continue our report.

"The Moon is rising over the horizon. Up here, it rises in /138
the north and sets in the south. Yes, that is correct. Yesterday, over Canada, we watched the Moon rise at 12:22 a.m. Just then we were coming to the Atlantic, and it appeared there. Now we are flying over the Amur and approaching the terminator. In a minute we will enter the shadow."

Earth received our report and warned us that our communication would end as we left radio-reception range. Our report ended here.

We saw forest fires several times over Africa, Australia, and South America. Every year they cause great losses to the economies of various countries.

In the future, there apparently will be effective space systems for monitoring the occurrence and growth of forest fires. Even fires in the most remote and inaccessible regions of the Earth will not escape their notice. Those on Earth will take steps to extinguish forest fires in time.

On different continents and in different countries we many times saw fields under different kinds of agriculture. There were noticeable differences between harvested, unharvested, and plowed fields. The boundaries between deserts and savannas, forests and steppes, and sandhills were clearly visible. Oil fields and burning flares could be seen on the open sandy desert.

On the 143rd revolution, a 11:21 in the area of the Dasht-e-Kavir desert in Iran, a large dust storm could be seen. Its

edges and its direction of movement could be distinguished. We sent information about our observations back to Earth.

The river network and all the lakes of our planet are clearly visible from space. The lakes in southern Africa were especially beautiful -- Tanganyika, Nyassa, Victoria -- as well as those in America, the Great Lakes -- Michigan, Superior, Huron, Erie and Ontario. But our Baykal was the most beautiful.

Mount Kilimanjaro snow-covered and with a dark crater in the middle, was splendid. /139

Twice we saw snowfalls and thaws in southern Chile and Argentina, in the region of Tierra del Fuego.

Large cities could be seen well. From space they are reminiscent of a cobweb, with a clearly delineated central part and with avenues and auto routes radiating from the center.

Airplane contrails could be seen. It was easy to judge from them which way the plane was flying. There were especially many of these contrails over Europe and America, as well as along international air line routes.

If the Sun is not at the zenith, the Earth's surface is clearly visible in one window, and you recognize by the landform what continent it is. In the other window, the Moon is visible against the background of a black sky. The plane Jupiter and the star Spica (the brightest in the constallation Virgo) are beside it. On the light side, Vega (the brightest star in the constallation Lyra), Canopus, and Sirius can easily be identified. The other stars are not at all or barely visible during the day; their brightness is inconsequential.

One of the most impressive sights is the brown Moon with white splotches against the background of a blue horizon. The Moon's color is very much like that seen in the photographs taken by American and Soviet space cameras.

Once, as we were flying over a sunlit part of our orbit and in a turning mode, we noticed a small amount of dust on the outside of one of the windows. The dust specks had what appeared to be a nucleus, thus giving the impression that they had just met the surface of the window at an angle and had broken apart. Ten to fifteen minutes before this, we had checked the status of all the windows, and there was no dust at that time. Our spacecraft had probably gone through a small cloud of space dust.

We often received inquiries from Earth about weather conditions in different regions of the globe, and we tried to make the appropriate observations clearly and communicate the result back to Earth. As we flew over our territory, we made several reports

on weather conditions. Sometimes we made weather forecasts for /140
for individual regions. For example, we predicted that a cyclone would come near Novosibirsk. The weather service used our on-board reports on meteorological phenomena in their current operations.

Here is one of the texts of a report we made on the 240th revolution. We began the report as our flight neared our territory and continued it along our entire flight path until we reached the Earth's dark side.

"The Sea of Marmora is beneath us. Cloudless and sunny weather, everything is completely clear. Ahead, the Black Sea. Istanbul is quite clearly seen. Absolutely everything: streets, squares, a ferryboat. We are going toward the Crimea, we see it on the left side of the flight path. The weather is clear over the Crimea, and we distinctly discern the cities of Simferopol', Sevastopol', Yalta, and Feodosiya, as well as the Arabat spit. The Kerch region is partly cloudy. The Sea of Azov is clear. The southern Ukraine has cloud cover -- six to seven units. On the right we see the Black Sea coast of the Caucasus. It is clear right up to Batum. We see Sochi, the Pitsunda region, and Adler well. There are airplane contrails near Adler on all sides. We see our citizens who are relaxing on the Black Sea coast. Now we are approaching Sochi. Vitaliy has leaned over to the window and is looking closely at his home town, where he spent his school years, where his parents live, and where he knows every street and every house. He says to me, 'Andrey, do you see the television tower and our house right beside it.' He sends greetings and good wishes to his parents and neighbors through Dawn. But Earth is asking us to continue our report. We are flying over the crest of the Caucasus. On the right, Tiflis, Yerevan, and Lake Sevan. In the cities, we see the streets, the city blocks, the glass roofs of businesses, which are reflecting the Sun's rays.

"On the left, Tsimlyan reservoir. The color of the fresh water is different from that of the salt water. We have already noted this many times. On the right, the Caspian Sea. Astrakhan is beneath us. Now we are flying directly over the Volga delta. The whole delta is visible. It is difficult to determine where /141
the shore of the sea is. There are large outflows and many different arms. A very beautiful sight, like the Nile delta. They are quite similar: huge, and defined by the line where the fresh water mixes with the saltwater. Now we are passing over northern Kazakhstan and Western Siberia. The lowland is flat and plowed, the cultivated land looks green and good. It is already more than a desert. A very lovely, civilized place. The great square and rectangular fields are clearly delineated.

"We are flying toward Novosibirsk. There is a strong cyclone here, and a front of cumulonimbus clouds extends for hundreds of

kilometers. The front is moving toward Novosibirsk. There is complete cloud cover beneath us, and the Earth cannot be seen. The terminator is in front of us on the flight path. Soon we will enter the Earth's shadow. From hereon, all Siberia is covered with clouds."

On this we finished our report. It lasted all of 15 minutes! All of 15! Earth thanked us for the information.

During the flight we made many observations of the day horizon. While making these observations, we clearly noted the effect of haze.- The day horizon line is blurred by a veil of this haze. Many cosmonauts in previous missions have often noticed this effect. The color of this haze depends essentially on light conditions: on the Sun's height over the horizon and on the presence or absence of clouds. Over the ocean, cloudy weather near the horizon is grayish-white; but if there are no clouds in the atmosphere, it is a bright blue. The color of this haze changes in a simple pattern as one looks up a vertical line -- from light blue (or grayish white) to a dark blue which merges into black. But the blackness of space is seen only through the window opposite the Sun.

During the mission we made many observation of the Earth's dark side.

While observing the Earth's surface on the dark side, cloud cover, individual, raised, and nonhomogeneous shapes were clearly visible. The Moon illuminated the "night" continents, and forests, rivers, lakes, and the shining upper edges of the clouds can be seen well. Without the light of the Moon, the Earth's surface can be seen, but not as well. The Moon's path -- its "reflected moonbeam" -- shown off the surfaces of rivers, but on the surface of seas and oceans, the entire "lunar pathway" could be seen. The coasts of oceans and seas, as well as individual islands, are clearly seen. Cities can be seen better at night than during the day, and the main avenues are distinguished from the rest of the streets by the brighter light. /142

One sees tens of cities at the same time, and we almost always identified them accurately. We saw large bright reddish-yellow flames, either singly or in groups. We saw especially many while flying over Africa and South America, but only a few in Europe. We could not determine exactly what these beautiful fires were, but we presume that they were flares of oil or gas well or fires from burning oil refinery wastes.

As we flew over the Earth's dark side, we could amost always see thunderstorms. The flashes of lightning sometimes even "play" -- they are reflected on the surface of the spacecraft. Once, during the 262nd revolution, we saw a rare phenomenon over East

Africa -- a ragged storm front several hundred kilometers long, with dozens of lighning flashes appearing at the same time.

On the 47th orbit, we saw an artificial Earth satellite, which was passing through Scorpio. Its size and brightness were about the same as seen from Earth.

Several times we saw the trails of meteors entering the Earth's atmosphere. The naked eye can clearly discern the trail of a burning meteor, but an optical-electronic instrument allows you to see it longer. We saw three large meteorites enter and burn up in the Earth's atmosphere; they came one after another at intervals of several seconds. Looking through the optical-electronic instrument we could see three parallel and adjacent trails, somewhat at variance as to the direction of entry.

The flight program provided for scientific tests of physical characteristics, phenomena, and processes in near-Earth space and for observation of heavenly bodies. These tests will be of great value in the future. The Earth's dense atmospheric layers are in continuous motion, and their optical properties are therefore not always constant. For this reason, it is difficult on Earth to get a clear picture of the stars, the surface details of the Moon and the planets. The atmosphere also hinders the recording of electromagnetic, corpuscular and other cosmic radiation. /143

When observing the stars from Earth, we see them twinkle; this is also because of the movements of the air mass.

From the latitude of Moscow, for example, we cannot see the constellations of the southern hemisphere. On a spacecraft at the edge of the Earth's atmosphere, the conditions for observing heavenly bodies improve several times over. In space, it is possible to see nearly all the constellations in one revolution around the Earth. Stars do not twinkle in space, since they are seen from outside the atmosphere.

Space observations of heavenly bodies are very important to science and to the solution of practical problems in astronomy and navigation. It is important to know starlight unchanged by th atmosphere. This will make it possible to determine the true brightness of stars, a knowledge of which is needed in order to make precise calculations of distances to the stars and, above all, to make accurate navigation instruments. In one of the experiments, we determined the brightness characteristics of Sirius and Canopus. Using the stars, one may orient a spacecraft precisely in space. By making angular measurements between stars, one may determine the spacecraft's position in orbit and calculate its parameters.

On the 224th orbit, we measured the angle between Arcturus and Deneb, stars in the constellations Boötes and Cygnus. We used the results of these measurements to ascertain the parameters of the spacecraft's orbit. The Southern Cross and Alpha and Beta Centauri are very beautiful. Incidentally, Alpha Centauri is closer to us than any of the visible stars. But it is still several tens of trillions of kilometers away!

We observed the heavens also through an optical-electronic instrument, which has a magnification of many times and which therefore makes it possible to observe weak and dim stars. The stars which penetrate the brightness layer can be seen well through it, and the brightness layer iself becomes clearer, more distinct and with more contrast. In the future, astronomical observations from space will of course increase our knowledge of the universe greatly. /144

During the flight we observed several rare phenomena, which we reported to Earth and which we described in our logbooks. Once, as we were entering the Earth's shadow, 8 minutes and 26 seconds after we had crossed the terminator and when the Sun had already fallen below the horizon, we saw silver clouds at the level of the mesosphere and against the background of the twilight. It was strikingly pretty, and lasted 2 minutes and 30 seconds.

It was very interesting to observe the Earth's night horizon. Right near the edge of the night horizon, a thin light band, which was slightly blurred, could be seen. We always saw a narrow, uniformly luminescent bright layer in the shape of a grayish halo with a rosy tinge above the Earth's horizon at a height of about 3.5°.

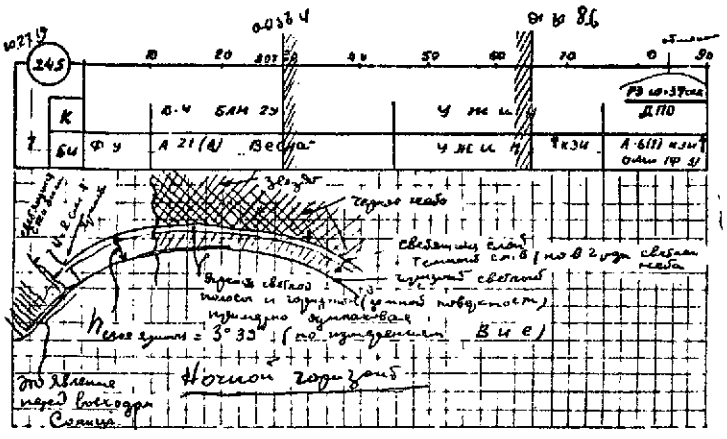
It is important to note that this halo has the form of a fine, luminous thread, which was at a constant distance from the Earth's surface wherever it was visible.

According to our visual evaluations, the brightness of this light band near the horizon and the brightness of the luminous halo are about the same. Futher toward the Earth's surface (below teh halo) there is a luminous ashy-gray haze, which is about half as bright as the halo. Above the halo only black space can be seen. The Earth's horizon is slightly blurred, and we determined exactly where it was by judging when a star or bright planet set behind it. The luminous halo has a barely perceptible fine and intricate structure. Sometimes we were able to discern several threadlike layers within it; these different in brightness and color. I note incidentally that the intricate structure of the luminescent halo on the Earth's dark side was also observed by A.Ye. Yeliseyev and V.A. Shatalov on Soyuz-8.

The optical properties of the halo are changeable and depend on how far the Sun is below the horizon. /145

Near the point beneath the Sun, the thickness of the halo gradually increases, and the halo becomes indistinct and blurred. In this area, the brightness layer of the night horizon begins to shine still more, blurring it above and below up to a height approximately twice that of the halo's height above the horizon.

Because the angle the Sun sets below the horizon is of critical importance in this regard, the luminous halo disappears in the area below the Sun; at the same time, the phenomenon of the space twilight is observed in this area.



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During our mission we took many measurements of the halo's height above the horizon, above the border of the night and twilight horizon, and we also measured the angular distance between the stars, planets, and the halo. We recorded the time the stars and planets lying in the orbital plane took to pass from the halo to when they set below the Earth's horizon and, similarly, to when the stars rose above the horizon.

Once, on the 245th orbit, just before the Sun rose, we saw the following between the dawn aureole and the night halo: a strong light effect in the shape of columns, which rose from a low band near the horizon to an altitude about twice as high as that of the night halo. The columns seemed a bit brighter than the night halo, and they were a yellow-gray color with a rosy tinge. While observing the column-shaped lights, we had the impression that the powerful beams of searchlights were shining up from the Earth's surface. /146

Once, as we were flying in the area of southern Australia and on the Earth's dark side, we observed for 7 minutes (1:04 to 1:11) intense vertical lights, similar to the northern lights, in the direction of the South Pole.

These lights looked like misshapen figures of various sizes, and they were yellow-gray with a rosy tinge. The intensity of the lights changed with time. Some figures disappeared, others got stronger, and new ones appeared. The vertical scale of the

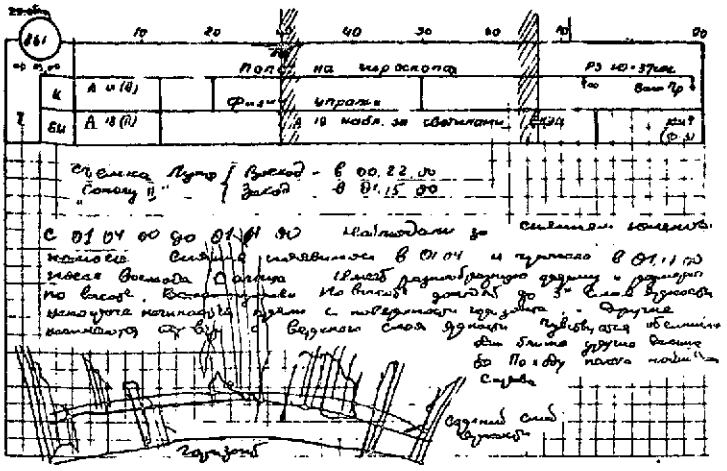
lights varied: some began directly on the Earth's surface, and others from the middle or top of the ashy-gray night layer. The maximum height was 10-12° above the horizon, i.e., they were up to three times the height of the ashy-gray night layer. Our visual perception sensed that the lights had a dimensional character: one part was closer to us, the other farther away. They were somewhat brighter than the night halo.

We saw these intense vertical lights twice more: on the next orbit, as we flew over Tasmania, and a day later, when we were again flying over southern Australia. These lights vanished after the Sun rose.

No less interesting was the Earth's twilight horizon as the Sun rose and set.

The dawn was seen at first as a small, bright, dark red crescent. Then it became light above the crescent in that part of the atmosphere which adjoined the lower part of the aureole. After this, orange-red and yellow tones were added to the dark-red tones. On the left and right sides of the crescent's axis of symmetry (in the shaded area), the luminous halo was seen at the same time. Those parts of the halo close to the crescent, but on the Earth's night side are "eroded" and assume a vertical, /147
blurred, threadlike shape. As the sun rises above the horizon, the cloud area colored by the dawn aureole increases. The red tones of the aureole brighten, and light and dark blue tones appear. This advanced dawn aureole then is tinged by the following color tones: red, orange, yellow, pale blue, whitish, again pale blue, again whitish, pale blue, dark blue, violet, and black. The first whitish belt has a delicate structure; it may be considered as being composed of two narrow whitish bands separated by a layer of light blue. The second whitish belt is seen along a great extent with a few breaks in a horizontal direction. The dawn aureole assumes its greatest dimensions just before the Sun rises. When the Sun's first rays appear, the aureole contracts and suddenly decreases its vertical dimension by a third. This sharp contraction of the twilight aureole the moment the first Sun's rays appear can be explained with reference to the physiological effect of vision on the human eye's adaptation to brightness.

When the Sun rises and the spacecraft is still over the /148
Earth's dark side, beyond the line of the terminator, the central area earlier occupied by the dawn aureole loses its color characteristics. The bright disk of the Sun stands out in contrast to the black background of space, and in the direction of the terminator to the left and right of the Sun (right up to the terminator and beyond) the characteristic light of the aureole is observed.



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As the Sun rises above the horizon (from 6-15°), an interesting phenomenon is observed at a certain point. This is the "moustache" effect, and it lasts for about 2 minutes. In the area of the terminator, a reddish dawn aureole seemingly cuts itself away from the Earth's surface and moves away from it strictly on a tangent toward direct sunlight into the zone of black sky to an altitude of 7 to 9°, i.e., 250-300 km. Symmetrical zones of light in the shape of "moustaches" and which have a vertical color range then form; this color range is analogous to that of an advanced dawn aureole. The color spectrum of the space dawn's "moustaches" remains as described, but the vertical scale of color tones changes: as the Sun rises, the dark-blue and violet part of the aureole contracts. An analogous phenomenon is observed as the sun sets, but here the altitude of the yellow-red part of the aureole diminishes. The moment the spacecraft crosses the terminator, the colored "moustaches" vanish.

This "moustache" effect -- the splitting of the night emissive layer near the border of the colored light zone -- has attracted great attention. The fact that the ends of the "moustaches," both left and right, extend visually beyond the terminator is probably caused by the specific conditions of sunlight and by the position of the observer in orbit.

Tests of the optical characteristics of the upper atmosphere allow us to elucidate much more precisely the processes by which solar radiation interacts with the Earth's atmosphere.

Scientific interest in this phenomenon stems from the fact that in order to obtain reliable data about our planet's surface and the meteorological processes taking place in near-Earth atmosphere from on board Earth satellites, it is necesary to know how to rid the information received from the equipment of the effects of the atmosphere. To do this, it is necessary to know the optical properties extremely well. /149

It also follows that attention be given to the possibility of using the luminous halo for autonomous navigation and

orientation of the spacecraft in Earth orbits. The advantage of such an orientation is that the luminous layer has a distinct and stable upper edge in the form of a bright and delicate halo. Therefore, the edge of the luminous layer is determined with confidence: there is significant contrast with the black color of space, and there is no intereference brought about by light scattering.

* * *

I would further like to discuss briefly the biological experiments which we conducted in space.

The main aim of the biological investigations was to study the effect of weightlessness and space radiation on the growth, development, and heredity of various kinds of living organisms.

The first biological studies must answer the question of how dangerous space flight is. Already on the second Soviet satellites space biology investigations were carried out. Subsequently, these studies were continued on the spacecraft Vostok, Voskhod, and Soyuz, on the Zond stations, and on the Kosmos satellites.

There were numerous animals and insects on the spacecraft; dogs (on the Soviet spacecraft) and monkeys (on the American ships), rats, mice, guinea pigs, DNA (desoxyribonucleic acid -- a protein constituent) preparations, Drosophila flies and Chlorella (one-celled algae), spiderwort (a houseplant), seeds and bacteria.

A detailed analysis of the structure of nuclei in the cells of mice and plants, the study of heredity in the generations of Drosophila and bacteria present in space helped in reaching the conclusion that manned flight for a short period outside the Earth's radiation belts will not be dangerous. However, space flight factors still can cause some disturbances in the organism. However, the question of the exact causes responsible for these disturbances remains thus far unaswered. In later flights, the aim was to investigate the effect of space flight factors on biological materialsin more lengthy experiments. Several biological experiments were conducted also with our direct participation. /150

On board Soyuz-9 were placed the following biological materials in special containers and cultivators: one-celled algae Chlorella, blue-green algae, seeds and bulbs of higher plants, potato tubers, and Drosophila flies in a special container.

Our experiment in which the effect of prolonged space flight factors on the developing Chlorella culture was investigated was

the first of its kind. The fact that cells, depending on their developmental stage, have different sensitivity to external influences is well known. It was assumed that even in our experiments it would be possible to detect a difference in the sensitivity of cells in relation to the duration of their development in weightlessness.

Chlorella was seeded on fasted agar (this was the special medium used) in metal containers. Before the beginning of the experiment all the recesses had been covered with metal filters blocking light. On the second day of the flight we shifted filters into the first three recesses in order to open access of light to the culture. Later, the filters were again covered after definite time intervals. Thus, the culture in recess No. 1 was in light for 1 day, in recess No. 2 -- 6 days, and in recess No. 3 -- for 14 days. After return from the flight, the Chlorella cells from all these recesses underwent analysis. The results of the analysis showed that in all the variants the survival rate of the cells was the same as in the control specimens, however the developmental dynamics of the cells exposed on board the spacecraft lagged somewhat behind the control variants.

Thus, no significant changes between the control and experimental series resulting from exposure to prolonged space flight factors were detected.

In our case, seeds and bulbs of higher plants were represented in another device (in a flask) on Soyuz-9. The seeds were /151
very convenient for conducting investigations. Soviet and foreign scientists had already previously investigated the effects of space flight factors on viability, physiological processes, cytological (cellular) and biological characteristics, and genetic (transmission of inherited properties) structures of a large array of seeds and bulbs of higher plants, such as Chinese cabbage, wheat, romaine lettuce, turnips, tomatoes, and carrots. The plants were selected from the species that can be generally used for prolonged cultivation in conditions of a closed area. On Soyuz-9, the effect of the 18-day space flight factors did not affect the germination, sprouting energy, and quality of the seeds and tubers of the plants.

Also included in the scope of the experiments with higher plants was the study of their possible participation in the biological-technical life-support systems of spacecraft in the presence of the factor of weightlessness. Selection of the cultures of wheat and potatoes stemmed from their food value and also their greatest viability.

When we had returned from the flight, specialists photographed the sprouts, measured the length and number of roots, shape of seedlings, and their orientation in space. After they had been

planted in a fixed location (on Earth), a study was made of the morphological structures of each potato plant by phases (number of shape of leaves, suchers, and flowers); observations were conducted with reference to seasons during the period of leaf formation, flowering, harvest (of tubers, leaves, stems, and roots), and chemical analyses of tubers and the remaining biomass as to dry material, carbohydrates, salt composition, and vitamin C content. These same analyses were performed also on the control plants.

Visual evaluation of the wheat did not show a marked differences in variants, from which it can be assumed that the 18-day residence of the seeds in conditions of an orbital space flight, in a state of profound rest, does not cause externally detectable morphological changes in the plants when they are subsequently grown on Earth.

In contradiction to this, the presence of potato tubers on board the spacecraft in a viable state caused externally detectable morphological changes of the sprouts. These changes were /152
expressed as follows. In the summer variant, the sprouts were oriented parallel to the cylinder, showing branching (offshoots), and their root system was less dense than in the control. Since the container was placed horizontal with respect to its longitudinal axis, after reaching the surface "upper" with respect to the position of the cylinder wall, the shoots turned further along their longitudinal axis. In the control variant the shoots extended vertically upward and had no branching. The probable cause of the well-defined morphological differences between the experimental potatot shoots can be the spatial disorientation of the auxins.

Several morphological differences were noted in the subsequent growing of plants up to the appearance of five to eight leaves, and thereupon the differences virtually vanished. In all probability the formation of these differences originated in the period in which the plants were on board the spacecraft and involved only the first stages of growth processes.

Thus, our experiments showed that factors of the 18-day space flight influenced the morphology of the offshoots of the higher potato plants. The changes were expressed in a marked difference in the structure of the vegetative organs (sprouts), their orientation and development. The possible cause of these changes is the disorientation of the auxins in the plant in the absence of terrestrial conditions of gravity. These changes in ontogenesis (in the individual life) of a plant are manifested mainly in those plant organs that were differentiated at the growth points during the period when the plant was exposed to the above-indicated factors.

The action of space environmental conditions has virtually no visible effect in dry wheat seeds in a state of deep rest.

It can be assumed that the conditions of weightlessness will have a great effect on the developmental processes in plants and can cause significant rearrangement of physiological processes occurring therein when the plants are in conditions of weightlessness.

To obtain an exact answer to the question of whether it is possible for higher plants to be used in biological-technical life-support systems of spacecraft in the presence of continuous or discrete weightlessness, we have to conduct suitable direct experiments in prolonged manned space stations. /153

Moving ahead of myself, I will state that they were soon carried out on the Soviet orbital station Salyut, where G. Dobrovol'skiy, V. Volkov, and V. Patsayev conducted observations on the sprouting of seeds in weightlessness conditions and other biological experiments, and also on the American Skylab station, where the American astronauts performed observations on little fishes and fingerlings appearing from their egg sacs while in space, and also of two spiders as they spun their webs in weightlessness.

"Falcon, I am Diamond, how do you read me?" (Diamond is the call signal of A. Leonov).

"Diamond, I am Falcon, I hear you clearly."

"Falcon, I wish to transmit a short letter to you: 'Papa, my dear papa, please hurry back from your flight. I warmly kiss you and you Uncle Vitaliy. Your Alena.'"

"Next letter: 'I warmly hug and kiss you both, I wish you a happy flight and most of all -- soft landing. We love you, we kiss you, we are anxious for you. Valya, Alena, Natasha, and Alevtina.' I am Diamond, how do you read?"

"Diamond, I am Falcon, I read you clearly, many thanks, Send our great wishes for these good letters, for the good wishes. And also tell them that everything is o.k. with us here. Everything is on schedule. We send them our heartfelt greetings."

"Diamond, I am Falcon 2, please transmit, if you will, our gratitude to our dear ones. Many thanks for these warm letters."

"Falcon and Falcon 2, I am Diamond. I definitely will do this, we will transmit. Everything is going fine with you."

"Falcon, I am Granite (this is the call sign of V. Shatalov), how do you hear me?"

"Granite, I am Falcon. I hear you well."

"Falcons, we follow you. Everything is going well. The doctors are already rolling up their sleeves, they are waiting until you return."

"We read you, give the doctors our best. Everything is fine with us, don't worry about anything."

"Falcon, how do you hear me?" Nikolay Petrovich Kamanin addressed me.

"Hear you fine!"

"How do you fell, how's your work capacity?" /154

"Good work capacity and alert attitude."

"Like always or somewhat worse?"

"Like always and even better. Everything's normal, everything is going fine."

"Good, continue in the same spirit."

"We read you, we will continue in the same spirit. Today the work pace was very high in these orbits. The program is very intense. But still everything is going normally, fine."

"Falcon, I am Diamond. We have noted your workload."

* * *

At a meeting devoted to the gathering of the crews of the Soyuz-6, Soyuz-7, and Soyuz-8 spacecraft, Leonid Il'ich Brezhnev said the following: "Our country has a broad space program designed for many years. We are going along our own approach, we are proceeding consistently and purposefully... Our approach to mastery of space is the approach of solving radical, fundamental problems, the basic problems of science and technology... The Soviet Union regards space research as a great mission in understanding and practical assimilation of the forces and laws of space in the interests of the working man, and in the interests of peace on Earth."

A graphic example of the fulfillment of this program is our extended flight on Soyuz-9, aimed at carrying out extensive scientific-technical and medical-biological experiments and studies.

During the flight observations of our planet were taken from space using optical equipment, photography, and motion picture

filming of areas, phenomena, and processes occurring on the Earth's surface. From the photographs taken from Soyuz-9 scientists were able to revise geological maps of different parts of the Earth and to determine the most promising area for mineral exploitation. In addition, from the photographs of individual parts of the world ocean it became possible to revise the directions of ocean currents and some of their characteristics. On the basis of these results, searching for zooplankton and the areas of accumulation of commercial schools of fish was simplified.

Photographs of atmospheric formations, snow and ice cover of the Earth yielded additional material for developing methods of developing long-term weather forecasting. /155

During the flight we photographed and relayed to Earth more than a 1000 frames of the Earth's surface, atmospheric and meteorological formations, the daytime horizon of the Earth, the atmospheric aureole of the Earth's twilight horizon and the water surface. We took photographs of different scales in black and white, color, and spectrozonal film. We obtained about 200 spectrograms of the Earth's atmospheric aureole and the underlying surface. We took motion picture films showing how cosmonauts live and work in weightlessness.

On the 188th orbit when our ship was over the western part of the Indian Ocean, an integrated meteorological experiment was carried out. In it, besides ourselves, the scientific research vessel of the USSR Hydrometeorological Services, Akademik Shirshov, and the Meteor weather satellite took part.

We took a series of photographs in approaching the Akademik Shirshov research vessel on the high seas, a second series of photographs -- while over the ship itself, and a third -- after flying past it. At the same time we took visual observations of the meteorological situation from an altitude of 230 km. While we were doing this, a group of scientists on board the Akademik Shirshov probed the atmosphere from below with meteorological rockets, made a vertical "profile" of the atmosphere, determined its characteristics, and took a great variety of other meteorological measurements. This enabled us to compare the readings and to investigate the three-dimensional structure of the atmospheric formations in this part of the globe.

The photographing of the Earth's cloud cover together with the Meteor meteorological satellite was performed by us over Africa, the Atlantic, and over the southern part of the Indian Ocean.

These experiments are vital not only because they enable us to study comprehensively the state of atmospheric phenomena, the

condition of the land surface, the World Ocean and the structure of the cloud cover, but also because they assist in improving weather forecasts and in finding new ways in interpreting data obtained from the Meteor satellite. Of course, in our flight they were preliminary in nature, but still they assisted us in /156
becoming certain of the utility of continuous carrying out of these experiments by means of long-term manned orbital stations.

We photographed the clouds and the underlying surface at the request of the weather service. We took these photographs while flying over the Crimea, the Volga, Novosibirsk, Baykal, and over other parts of the Earth. We photographed atmospheric fronts with dense cumulonimbus clouds and incipient and decaying cyclones.

These photographs yield additional material for developing techniques of long-term weather forecasting and methods of recognizing the times at which cyclones and typhoons are born.

Long-term weather forecasting is of vital national-economic importance. The problem of long-term weather forecasting requires knowledge of the condition of the atmosphere over our entire planet. Long-term manned orbital stations will be used for these purposes. At the present time, the automatic Meteor meteorological stations are responsible for the "weather service." The weather service daily obtains hundreds of telemetry photographs from these satellites. They characterize the features of the atmospheric formations of the Earth and determine regions of formation of typhoons, cyclones, and hurricanes, and the distribution of cloud covers and jet streams. Based on this information, weather forecasters have more than once warned the population of different parts of the Earth on advancing hurricanes and typhoons. This enabled timely measures to be taken and large losses due to natural calamities to be avoided.

Meteorologists are interested in problems of studying the spectrum of thermal radiation escaping from the Earth into outer space. These observations make it possible to provide a vertical "profile" of the atmosphere and to determine at different altitudes, temperature, humidity, atmospheric pressure and to obtain other meteorological data.

By means of special instruments from spacecraft, one can measure the temperature of the seas, oceans, the Earth's surface and the atmosphere at different altitudes.

This information obtained on a global scale would make it possible to provide reliable long-term weather forecasts with high accuracy.

So-called aerosol probes are carried out with instruments /157
from manned spacecraft. During these periods the vertical profile of the concentration of dust particle (aerosol) in the Earth's atmosphere is determined.

The atmosphere contaminated by discharges from industrial centers and volcanic dust leads to a considerable reduction in the effectiveness of solar radiation and to a considerable weakening of the thermal flux received by the Earth's surface.

Data obtained from manned spacecraft yield information on the optical properties of the atmosphere, and the distribution of the aerosols in the Earth's atmosphere. These data are also used in weather forecasting.

Processes occurring on the Sun strongly influence weather. There is a direct link between solar activity and weather conditions on the Earth. And better we study this link, the more reliable will be our long-term weather forecasts.

The entire range of solar short-wave radiation: ultraviolet radiation, X-ray and gamma radiation -- owing to the absorption in the Earth's atmosphere can be investigated only beyond the atmosphere. These radiations provide basic information on the Sun, space objects, and physical processes occurring in the universe.

Using special counters, fluxes of X-ray and other rays are recorded on spacecraft. Their direction and energy... are determined. Photons of specific energies are recorded; and idea of the spectral composition of radiation can be obtained. Using X-ray photographs of the Sun taken from onboard spacecraft, active zones of the solar surface are defined.

Scientists have obtained interesting results from studies of the ultraviolet region of the solar spectrum. The ultraviolet radiation of the Sun is born in the outer regions of this heavenly body. A study of information conveyed by these rays will assist in better understanding the structure of the solar chromosphere and corona, processes of interaction of magnetic fields, the reasons for proton flares being initiated, and other processes occurring on the Sun.

An exact knowledge of all these processes will significantly /158
assist in improving the forecasting of weather conditions on Earth.

Of course, infrequent flights of manned spacecraft can yield only fragmentary data for the needs of the weather service. The basic information here must come from meteorological satellites. However, in the not distant future when long-term scientific orbital stations with crews on board will be regularly functioning in space, meteorological observations taken from them by specialist meteorologists will substantially supplement and revise meteorological data obtained from automatic satellites and ground stations.

What can future orbital laboratories provide for the needs of the meteorological service?

Today mankind has already "girdled" the planet with a network of meteorological stations. In just our country alone, they number more than 4000. There are 7-1/2 thousand meteorological stations. Hydrological observations are taken at 6000 stations. More than 200 stations probe the atmosphere with radio waves. The meteorological service has its own ships and aircraft that "keep track" of the weather. The chief meteorological center receives information from all corners of our country. The more than 700,000 telegrams a day represent the volume of transmitted information. But this represents only data for our country. The "kitchen" where weather is "made" does not have a permanent location, and on the global scale its secrets still remain a great mystery for us.

Meteorological automatic satellites have become a unique tool in the hands of weather forecasters, playing a tremendous role in the achievements which have now been gained and which are already providing for various aspects of the weather service. And one can imagine how broad our opportunities in forecasting particular weather phenomena will expand if round-the-clock observations can be made not only by automatic devices, but also by the specialist weather forecasters themselves!

It suffices to state that in just one revolution around the Earth information about cloud cover over a territory representing about 8% of the globe can be acquired from space altitudes, and data on radiation fluxes can be obtained covering roughly 20% of /159
the Earth's surface. During a single revolution of an orbital station, a volume of information can be collected that is 100 times greater than the amount of data coming from all meteorological stations of the world, and they number more than 10,000!

In order for these figures not to seem only a quantitative measure of science and technology, let us analyze their economic aspects: forecasts of the USSR hydrometeorological service, which draws upon the Meteor type satellites, according to far from complete data, has meant the savings annually of material values amounting to 500-700 million rubles.

Orbital patrols can warn of possible disasters at once much faster and more effectively than can ground services. This will reduce the possibility that a storm will unexpectedly break out on an unwarned and thereby unprepared region. It is well-known what such storms and typhoons entail. The terrible calamity that a typhoon brought to the coasts of the Bay of Bengal, killing 200,000 persons, is fresh in memory.

The World Meteorological Organization has calculated that further improvements in weather forecasts will mean in the

immediate future that the planting and harvesting times throughout the world can be determined to such a precision that this will make it possible annually to save 15 billion dollars that are now being lost.

Can automatic weather forecasting satellites completely meet all of our needs or is it best to combine them with observations by man himself, on board the space laboratory?

This question can be answered with facts. Here, for example, we saw that during the flight of Soyuz-6 the crew discovered tropical storm Jennifer along the coasts of Mexico and reported about this sooner to the meteorological station than the same data arrived from an automatic satellite. When ground asked us about the state of weather in different parts of the planet and over our own country, we made the appropriate observations and quickly reported on them to Earth. We also reported on the weather from the coast of the Crimea to Lake Baykal. On sighting a cyclone in the area of Novosibirsk, we reported on its approach to the city. Valuable meteorological information was transmitted from the Salyut orbital station by G. Dobrovol'skiy, V. Volkov, and V. Patsayev. /160

Space also offers to play an important role in developing means of navigation.

"Where am I?" This question is asked many times during a voyage by the navigator of an aircraft or a ship. Determining one's position when on dry land close to some noticeable reference marks or inhabited places is not such a difficult matter. But how would it be if a ship or an airplane is far from coasts or even in bad weather? Without knowing exactly one's location, neither can a captain alone bring his ship along the shortest route to his port of destination. Fishermen, submariners, and aviators have their own complexities.

Now let us imagine a dispatcher station in orbit which gives to ships and satellites all needed information in order to ensure safety, exact and rapid tracking along an economically advantageous route from one point to another. As for the fishing fleet, the exact determination of their location enables fishermen to rapidly and by the shortest paths to sail into rich commercial fisheries.

The importance of the problem is already obvious today. And if one considers that in the mid-1970's voyages of passengers and cargo by sea-going and aircraft transportation compared with the close of the 1960's will increase more than three times, the economic benefit from space navigation will be even more tangible: in freighters, for example, it will be possible to bypass

determining the ship's location from celestial bodies, which involves annually nearly 380 hours by the ship's helmsman.

And so, orbital beacons open up the path to building a universal "road sign." According to UNESCO calculations, data obtained from space navigation services will make it possible on the average to shorten the length of transoceanic trips by 45 minutes a day. If one starts from the present size of the oceanic merchant fleet (about 200,000 large-tonnage vessels), /161
building orbital navigation services will yield an annual savings at the level of hundreds of millions of dollars.

Aircraft can complete flights along the shortest routes, which will save by 20% the time that they are enroute and appreciably cut the cost of transatlantic flights.

But what will happen in several years? According to calculations of British economists, in several years about 30,000 ships with displacement of 100 or more tons will be cruising in just the Atlantic Ocean. In addition, in the not distant future there will be no fewer than 500,000 fishing vessels in the Atlantic Ocean, including about 200,000 vessels in the North Atlantic. And exact navigation data are essential to this entire host of seiners, refrigerator ships, floating canning plants, cargo and passenger vessels. "Cosmic beacons" will provide them these data.

Orbital dispatcher stations can perform the task of detecting icebergs and observing their migration. They will announce warnings of ionizing radiation to high-flying aircraft over certain parts of their flight route.

In discussing the tasks of the present day, we have already seen: the time is drawing near when the mastery of space will become economically profitable. Space technology is being more and more widely used to improve the weather service, to simplify, improve, and extend lines of communications, and is being placed at the service of marine navigation. Then the fields of use of space technology will be expanded. For example, it will participate in monitoring plantings, studying the World Ocean, and in geological investigations. This is already quite realistic. Of course, expanding operations in space doubtless must be associated with a reduction in outlays in delivering cargoes to orbit and back to Earth again.

All these are the most intriguing prospects. Their complexity is now inspiring.

Man is characterized by the striving to analyze the past and delve into the future. And this future in our turbulent technical age is bound up with space.

* * * /162

14 June 1970 was the day of elections to the Supreme Soviet of the Union of Soviet Socialist Republics.

On this holiday all Soviet people cast their votes for the best sons and daughters of our great Homeland.

Vitaliy and I during the flight took our certification for the right to vote in the USSR Supreme Soviet elections. And together with all Soviet people we participated in voting.

On 14 June, 8:15 a.m., on the 205th orbit, we sent the following radiogram to the Space Flight Control Center:

"Dear comrades!"

"Today, 14 June, when all Soviet people are choosing deputies to the highest organ of state power of our country, as crew members of Soyuz-9, and now finding ourselves in the expanses of the universe, we join ourselves with a sense of high civic duty to all the electors casting their votes for the best sons and daughters of our Homeland and for candidates of the inviolable block of communists and nonparty people. On this solemn day we, like all the Soviet people, vote for the further flowering of our socialist Fatherland, for our Communist Party, and for communism.

"Soyuz-9 ship commander, A.G. Niklayev.

"Flight engineer of Soyuz-9, V.I. Sevast'yanov."

14 June 1970 marked 7 years from the launch into space of Valeriy Bykovskiy on Vostok-5.

On the 206th orbit we request Dawn to transmit our sincere and cordial congratulations on the seventh anniversary of the launch of our comrade and friend Valeriy Bykovskiy and our wishes for the kindest and very best future for him and for many more space flights to come.

"Falcons, I am Dawn, thank you, we will definitely pass on to Valeriy Bykovskiy your congratulations and well wishes."

"He actually is celebrating?"

"After work he lay down to rest (Valeriy Bykovskiy was in the /16
flight control group)."

"We understand. Well give our greetings to him."

"We will do so, I am Snowstorm, how are you? (Snowstorm is the call signal of Anatoliy Filipchenko)."

"Hello, Snowstorm! Hello, Snowstorm! Send Valeriy our congratulations and tell him: we have taken 10 sips of juice in honor of his health."

"We understand, I am Snowstorm." And add some sips of vodka to the ten swallows."

"Yes, we will drink vodka, we will have some."

On the 210th orbit, a television representative communicated to us through Dawn.

"Falcon, I am Dawn, how do you feel?"

"Dawn, I am Falcon. Today we are beginning our workday in a festive way. We feel good, elated. Our attitude is excellent."

"We understand you, Falcon, thanks. Today a question to Falcon 2: has your sense of time changed?"

"I am Falcon 2. To some extent it has. Here time flies so fast, so fast that you simply cannot plan everything and carry out everything as you should."

"... Today already the pace of the day to which we have been accommodated is not at all like an Earth day. Here we live by artificial days. We go by days that are built around purely the working conditions of Control Center, which involves the route, and how the flight route passes over the Earth's surface. That is why our days are relative and the time scale is altogether different."

"Thanks, Falcon-2, we understand. We wish you the successful completion of your flight program."

"Thank you."

On the 224th orbit the Chief Designer communicated with us. He warmly greeted us and asked with concern: how did we feel, how was our attitude, had we adapted to the space environment?

Vitality and I were very pleased to hear the quiet voice of our Chief so very close to us. We answered the Chief that we felt fine and our attitude was excellent. We have long since adapted to the space environment, we felt at home in the ship and /164
we had become a part of it. We were ready to perform the flight mission in full and ultimately even to do some more (we had in mind continuing the flight to the twentieth day). We had a food reserve for two days.

"Yes, yes, Falcons, young fellows, of course, all is correct, let us see, let us think about it. We will weigh everything and tell you our decision."

"We understand, many thanks."

Following the Chief Designer, Nikolay Petrovich Kamanin was placed in touch with us.

"Falcons, Valentina phoned me a little while ago. She's in Moscow and she is meeting with Alevtina. Everything is fine at your home. Both of them together with Valentina Gagarina send you greetings and best wishes. How do you read?"

"Thanks. Many thanks for the greetings and well wishes. Send them our best. Everything is going normally here, nothing to report, everything is being performed as planned."

"We now can see you by television. You look remarkably well. From your television images it is clear that you look fine and have a good attitude. The specialist physicians have come to a conclusion. They say that you are holding up as fine fellows. Continue in the same spirit."

"Yes, yes, we will continue in this spirit. Everything is o.k. with us."

"Good, thanks, have a happy flight!"

"Thanks!"

On the 237th orbit the conversations with N.P. Kamanin continued.

"Falcon, good morning. How do you hear me?"

"Good morning, we hear you fine."

"I sent Vitaliy's and your greetings to Valentina, Alevtina, and Valentina Gagarina. They thank you and wish you success in the rest of your flight."

"Thank you, thank you."

"Today I have a request of you. Yesterday you said to the Chief Designer that you and Vitaliy have two days reserve food supply. I would wish to know what is in this reserve because we thus far cannot find what you must have left."

"Our food has been accumulating since the first days of the flight, because at first we did not eat everything up. These /165

leftovers are quite carefully stored and placed in the reserve. And already on the first day we fell asleep rapidly and the food scheduled for the entire day was not fully consumed. As all told we have built up a food reserve for about 2 days. That is what I reported about yesterday."

"Good, this is clear to me. Only we must remember that everything that was not used during the first day, according to the program, was used on the second half of the next day.

"This is understood. The subsequent day, in the latter half of the day. Still, I say that food remains."

"Well it is clear to me that you really don't have other reserves?"

"No, no other reserves."

"Understood. You have been eating everyday as scheduled?"

"Yes, we have been eating everything. We twice ate two little bags of preserved meat from those reserves."

"I understand you."

"Dawn, I am Falcon. Today is 16 June. Seven days since the launch of Valentina into space on Vostok-6. For this reason I ask you to transmit to Valya Vitaliy's and my heartfelt congratulations on her launch into space and our best wishes."

"Falcon, I am Dawn, I definitely will transmit, we will congratulate her, by all means."

"Thank you, I am Falcon. We here are busy with the general housecleaning, we are putting everything into shipshape."

"We read you, this is fine."

"So long!"

243rd orbit. We again come into ground contact.

"Falcons, I am Dawn. With me there are specialists and they are interested how intense is your program of research and experimental work?"

"Our flight is full of a great deal of scientific research work, and carrying out technical and medical-biological experiments. We perform many experiments several times in order to build up the necessary statistical data. In general, there is a great deal of work. Our flight actually is a true working flight."

"We read you, I am Dawn. Here is the last question: have there been any experiments with you and Falcon 2 that are your favorites?" /166

"Yes, there have been. For example, I liked best the experiments involving carrying out dynamic operations."

"And Vitaliy's favorites?"

"I also have some. I like best of all the navigation experiments. Here we developed a new navigation system. Quite likely we obtained fairly good results. When we returned to Earth, specialists will rate these results. And if they prove to be good, we will be very pleased."

"We read you, thank you. How does Falcon 2 feel?"

"I feel fine. I'm feeling okay. The preparation for the flight under the special program and the training in general helped be tolerate this flight very well. I feel excellent. My work capacity is just like it was on Earth."

"Thank you, we read you, I am Dawn."

* * *

Space motion picture and still photography was a definite part of the 18-day flight program. On Earth we took the appropriate motion picture training. We developed plans and subjects for space photography and coordinated them with the subjects of ground experiments. Ground training helped us a great deal in space in choosing the plans, foreshortenings and composition of the various episodes.

On flying over our planet with camera in hands when you see the unrepeatable pictures of the Earth from space altitudes, when "at each step" you make as it were discovery of the "landscapes" of space, involuntarily you wish to film the most interesting, most expressive and most exact.

From space Earth looks very beautiful, so that at times you can hardly tear yourself from the window. There is much that is curious and interesting. The locale changes very rapidly beneath us. A particularly interesting cloud formation may not even be repeated in equally convenient and impressive conditions for photography as appears at any particular moment. During the flight we tried to film the most interesting in order for the frames to be full of content and serve as a scientific document. /167

Photography from on board the spacecraft is highly specialized. When the ship is flying in the oriented position, one can

quietly take motion picture films of the area being overflown, sighting ahead of time an object toward which one is approaching and one can prepare to film it. But the ship is quite rarely in an oriented attitude, and most often it is in the rotating regime, that is, spinning about some axis. In this condition filming becomes difficult, since the window through which you can film is continually leaving the Earth's surface, while another window is approaching it. In this situation you have to rapidly move from one window to another, work efficiently in order to catch the interesting phenomena occurring in the Earth's atmosphere and the fascinating landscapes.

Characteristic geological formations of the Earth's surface, coastlines, lovely islands with volcanoes, mountain ranges with snow-covered peaks, plant and snow cover of the Earth's surface, rivers and lakes, cloud formations, and atmospheric effects such as thunderstorms and cyclones, dust storms, and ocean storms were all photographed. The line of the terminator during entry and departure from the shadow was recorded on motion picture film. The spinning of the ship was kept track of by the parts of the ship visible in the cabin window against the background of the Earth. We took the various phases of the rise and descent of the Sun and Moon.

The photography program provided for subjects related to the scientific-technical and medical-biological experiments and studies we were carrying out. We wanted to emphasize in our motion pictures how freely a person feels in space, how he can do complicated work.

We took frames that showed the crew operating in controlling the complex ship system, working with scientific equipment, working with the onboard navigation equipment, the motion picture camera, the onboard television camera, performing physical exercises, and much else besides.

Everyone knows that much in life and work depends on your everyday routines. Therefore in our film we wanted to show also the everyday conditions that took form in our craft. We filmed the /168
full routine of our everyday life. We tried to a show a typical day in a cosmonat from reveille to retreat, and to more accurately depict our everyday space routines. The motion pictures showed the morning personal hygiene of a cosmonaut: how he shaves, brushes his teeth, washes, and dresses. We took turns in filming each other. Once I filmed Vitaliy in his morning personal hygiene. When he had completed everything, he suddenly asked me: "Keep filming more." Upon saying this, he suddently made a somersault in front of the camera lens. This episode was captured in the film not poorly, in our view. And this space "life" episode revealed not some bit of mischief, but the physical freedom and psychological unleashing of man in weightlessness and his marvelous adaptation to this new world. If a cosmonaut turns somersaults,

if he is cheerful and buoyant, this means that everything is fine with him, everything is going normally as scheduled.

After the morning personal hygiene we ate our meal. And this episode was also filmed. Here we showed the food heater, how tubes containing coffee or soup are inserted into it to be warmed, how the cans are pierced, and how they are secured. If they are not secured, they can float freely. And we showed how freely a tasty piece of meat or some piece of candy can escape us.

The film also showed our comfortable sleeping bags and their use. We tried to show in detail how we performed our physical exercises.

When we took the films, we always tried to make them not only chronological, but also to have philosophical meaning, to stir the viewer, to compel him to think on what he had seen.

We spent much time in special photography and spectrography of objects in space.

During the flight we performed several experiments investigating the brightness of various subjects in the visible region of the spectrum.

Using a modified manual satellite spectrograph, we performed spectrophotometry of the Sun (here we estimated the effect of spectral transmission of solar radiation through the spacecraft windows) in a series of several frames each when the Sun was at its maximum height above the horizon.

Spectrophotometry of the nighttime horizon was performed at /169
the moment the glowing layer appeared at the horizon, and of the twilight aureole of the Earth's atmosphere from the moment the glowing layer appeared on the horizon and before the complete emergence of the Sun from below the horizon. There was also simultaneous photography and spectrophotometry of the daytime horizon, clouds, and the underlying surface of the tropical forests of Africa, the swamps around Lake Chad, the Nile River delta, the Gulf of Kara-Bogaz-Gol, the Sea of Aral, Amudar'ye, the Syrian Desert and the Volga. These photographs were taken to study the brightness and color pattern of the aureole, the vertical distribution of various atmospheric components, and the various natural formations of the underlying surface to study the possibilities of identifying them from spectral reflection characteristics measured from space, and also to determine the upper boundary of clouds photographed from meteorological satellites.

During the flight an integrated experiment on spectrophotometry of the underlying surface was carried out along the route of the Kara-Bogaz-Gol Gulf -- Ustyurt -- Sea of Aral.

The results we obtained from space were compared with synchronous measurements of brightness and contrast from an aircraft using a similar kind of spectrograph. This comparison made it possible to estimate the transfer function of the atmosphere.

Through further study of the spectra of the underlying surface absolute values of spectral brightness, coefficients of reflection, color characteristics of different types of underlying surface, as well as spectral contrasts between different types of natural surface will be obtained.

A series of scientific experiments investigating near-Earth space, photographing the daytime and twilight horizons of the Earth and of the Moon against the background of the Earth's horizon were also carried out. The Moon was photographed as it was tangent to the upper and lower boundaries of the glowing layer over the horizon, the boundary between the atmosphere and the Earth, which in particular made it possible to improve the characteristics and increase the precision of spacecraft orientation systems.

Space photography is vital for geology, geography, and the study of the underlying surface and the World Ocean of our planet. The photographs (and they can be of various kinds: black and white, colored, and spectrozonal) are the most important source of information on the Earth and all kinds of phenomena in its atmosphere. They can be used for the interests of various sectors of the national economy. /170

The main aims of our experiments conducted as part of the investigation of the Earth's natural resources were these: determining the optimal conditions of photography for the needs of geology; developing and improving methods and techniques of obtaining photographs and methods of processing photographic information, that is, an understanding of what is represented in the photographs so as to interpret details from the geological point of view as well as to solve applied problems in the use of this information for diverse scientific and practical purposes in oceanology, hydrology, geology, geomorphology, geobotany, soil science, and industrial, agricultural, and forestry geography.

To solve problems in geological mapping and searching for materials, at the same time that photographs were taken from on board the Soyuz-9, aerial photographs were taken from aircraft of specially selected proving ground sectors most representative as to geology and geography. Ground geological and spectrometric investigations were also carried out in these proving ground-sectors.

This integrated conduct of the experiment was carried out in the areas of the Northern Caucasus, Caspian and Aral seas, Kazakhstan, and Western Siberia.

As a result of the experiment, a great number of photographs of high photographic and photogrammetric qualities suitable for geological interpretation were obtained. The extent of the individual routes was 1000 to 2000 km.

Besides the regions covered by route photography, we photographed different parts of the Earth's surface containing locales containing relief that was characteristic from the geological and geographical point of view -- the south of the European part of the USSR, the mountain ranges of the Northern Caucasus, the region adjoining the southern part of Lake Baykal, the territory of the Mangyshlak peninsula, and the coastline of the Pacific. /171
These space photographs open up broad prospects for regional plots and clarification of the irregularities of formation of geological structures determining the distribution of deposits of oil, gas, and other minerals and their structural monitoring.

The experience in geological interpreting of photographs of the Earth's surface taken from space showed that these photographs can be used both for resolving problems of global geology as well as for revising, refining, and compiling geological, geographical, and different kinds of specialized maps at scales of 1:200,000 and smaller.

In recent years planetary geology studying the laws of motion of continents, enormous breaks in the Earth's crust extending sometimes hundreds and thousands of kilometers, has been developing vigorously. These faults can also be seen from space altitudes. Their study will make it possible to determine the general regularities of geology structures on the planetary scale and to understand the distribution of minerals.

Scientist believe that outcroppings of many minerals accompany the breaks in the Earth's crust.

An exact knowledge of the location and structures of breaks in the Earth's crust is of enormous significance in solving national-economic problems not only from the standpoint of determining the assumed areas of mineral deposits but also in solving other integrated problems here. For example, after studying the geology of Belorussia it became clear to scientists why following the draining of a marshy locale in one region, suddenly meadows located in quite a different region 150 miles away from the marshes began to dry up, unexpectedly to all concerned. It turned out that the meadows and the marshes were on the same fault of the Earth's crust and the meadows were being fed by water coming from the marshy regions along this crack.

Scientists believe that Lake Baykal, the lakes of Northern Mongolia, and the Caspian and Black seas, from the standpoint of planetary geology, are only details of one giant fault.

The location of small and giant faults in the Earth's crust can be readily seen in photographs that we took from Soyuz-9. These photographs will be of great assistance in the further study of the fault structures.

Space photographs offer broad possibilities for studying the nature and intensity of modern technical and physico-geological processes. Photographs of Lake Issyk-Kul' -- the epicenter of the July 1970 earthquake, that we took from orbit on instructions of the Flight Control Center during and immediately after the tectonic event -- are undoubtedly of high interest in resolving these problems.

Also of great interest are the photographs we took of the Volga River delta in which the direction and intensity of the entrainment of alluvial material can be seen. Also of high interest are photographs of the Gulf of Kara-Bogaz-Gol showing considerably alterations that have occurred in the gulf in recent years.

In space photographs one can clearly trace the bedding of bedrock. The photographs make it possible to revise fundamental laws of orogenesis.

Different kinds of minerals lie in specific geological structures. They can be distinguished in the photographs by characteristic features of macrorelief and by outcroppings of bedrock at the Earth's surface. This enables specialists to find the regions where detailed geological exploration should be conducted. Study of the makeup of the Earth's crust and the inhomogeneity of its mass, and exploration of gravitational and magnetic anomalies from the spacecraft will assist in opening up regions in which various minerals can be found.

Earth zealously stores its treasures like a sealed book. Not days, but months and even years must be spent in order to detect them in the taiga debris, mountain steeps, and unpopulated deserts. Exploratory drilling is not as simple as may appear at first glance. Overcoming each new hundred meters into the planet's interior involves great difficulties.

In order not to drill fruitlessly, one must know the general regularities of the occurrence of minerals and power sources.

Nature can be overcome and the "locks" to its storehouses opened, without touching them by hand, by means of spacecraft. The problem is not easy, but it is solvable, and much has already been resolved.

Specialist geologists have carried out photogrammetric processing of photographs taken from the automatic stations /173

Zond-5, Zond-6, and Zond-7, from the Vostok, Voskhod, and Soyuz spacecraft, from the orbital station Salyut, and in television photographs taken from Kosmos and Meteor satellites. Here there was also interpreted large numbers of photographs taken during our flight on Soyuz-9. The outcome was that the compiling of geological maps using space technology will help us in the future determine the character of tectonic formations and other crustal inhomogeneities that will serve as unique reservoirs of petroleum, gas, coal and so on.

The first observations from orbit and the interpretation of photographs yielded highly encouraging results. Scientists believe that even greater prospects will come from integrating photography when simultaneously images are taken of the Earth's surface and natural objects in different regions of the wavelength spectrum with the use of infrared, laser, and radar photographic techniques.

Study of the geomorphological characteristics of a locale and the relief types, in particular, breaks and shifts in crustal plates will help geologists predict the occurrence of ore deposits and simplify searching for minerals.

Scientists have already found a relationship between the geological structure of the Earth and the intensity of its magnetic and electric fields. But geologists have to know not only the fundamental dependence, but also specific relations. It turned out that for a more exact determination of the magnetic or gravity field of the Earth, the measuring instruments must be as far as possible from the planet's surface. Therefore, orbital laboratories are the best location for these instruments. Geologists can use them to gather data of interest to them in clarifying the regions containing potential stores of minerals, ores, petroleum, and other useful deposits.

Two thousand years ago Eratosthenes measured the "waist" of the planet and established that the radius of the Earth is about 6000 km. This "approximate" figure -- a little more or a little less -- appeared in numerous treatises for 19 centuries. More /174
than 200 years was required for geodesy to clarify age-old problems associated with the geometry of the Earth. But thanks to spacecraft, these problems were solved in only 2 years with amazing meticulous accuracy.

In spite of the thousands of years of man's history, still about 40% of our planet does not have detailed maps. At the present time only a small part of the planet's surface has exact maps. This can be explained by two factors. First of all, nature has so created the Earth that on it there are numerous inaccessible regions. Secondly, compiling exact maps is not as simple, and importantly, not at all an inexpensive matter.

In our country owing to the vigorous growth of the national economy, with each passing year new industrial enterprises, hydroelectric power stations, enormous reservoirs, and open pit mines, airports, roads, and new cities spring up in various regions. All this requires from cartographers timely correction and updating of maps. Photographs of extensive territories taken from space will assist cartographers in substantial revisionof maps of parts of our territory and also in the exact determination of the exact coordinates of islands, reefs, sandbanks, and remote inhabited localities and objects.

In the future numerous and systematic observations will furnish material for verifying the widely held, although debatable hypothesis of continental drift, and the quantities of surface and subterranean water on continents.

Future space expeditions will extend our concept of the seas and oceans and will promote a fuller understanding of the processes occurring therein. In this lies the key to the effective utilization of their economic potential.

Since spacecraft appeared, geographers have made amazing discoveries. For example, satellites helped in determining the exact position of the Bermuda Islands discovered as long as 400 years ago. They were found to be 66.88 meters more northerly and 31.92 meters more westerly than had been earlier assumed. Satellites established that the equatorial diameter extending from the eastern tip of Brazil to the Admiralties is approximately /175
45 meters longer than the diameter perpendicular to it extending from southern California to the southern part of Iran, that the area of the northern hemisphere of the Earth is somewhat larger than the area of the southern hemisphere, that the distance between Paris and Washington is increasing each year by 4 meters and that Buenos Aires was shifted 15 meters toward one side over a 7 year period.

Geographers (as, by the way, is true of persons in many other specialties) need accuracy. The use of spacecraft for the purposes of cartography, according to U.S. data, has meant an increase in the precision of measuring distances on the Earth's surface up to 1-1/2 meters, and in the near future it is assumed to increase this precision to 30 cm. As for the annual savings by use of the new method, it is 700 million dollars. But even this is not the whole picture. We will obtain from space an idea of human activities on the Earth's surface, types of rural and urban populations, the intensity of land use, the ramification of transportation networks, and so on, and we will be able to investigate the dynamics of numerous phenomena.

Space photographs interest not only meteorologists, cartographers, geologists, but also oceanologists, fishermen and workers in agriculture, forestry, and many other sectors.

Study of the enormous marine expanses from space can provide great assistance to oceanologists in solving many urgent problems. Our Earth is 70% covered by water. And the resources of the World Ocean are enormous, but it has not yet been exploited. Fishing vessels of various nations are plowing through numerous regions of the ocean and the seas. Annually they haul in enormous quantities of fish and aquatic life. Exploration work is underway to determine the regions where schools of fish accumulate. Oceanologists have established that the migration and density of fishing schools, herds of aquatic animals, and accumulations of zooplankton depend on the condition of the bodies of water, currents, temperature, degree of water mixing, chemical composition, salinity, and density of water. Schools of fish concentrate /176
where there is nutrition for them -- in the regions of accumulation of minute aquatic organisms -- zooplankton. Commercial schools of fish travel mainly to depths not greater than 15 meters. In swimming they excrete specific fats, which can be clearly distinguished by their spectral characteristics in the water surface and from them the locations of fish school accumulations can be determined. Space laboratories with crews on board can do this very exactly and rapidly. They will provide specialists with reliable operational information on the scale of the entire World Ocean and thus provide great assistance to a considerable increase in the commercial hauls of aquatic products.

Agricultural crops, vegetation, and forest tracts of our planet have highly characteristic radiation in the range of red and the infrared region of the spectrum close to it. Detailed analysis of this information makes possible practical steps in using space studies in solving urgent problems in agriculture, forest farming, and other sectors of the national economy.

Specialists on orbital laboratories using specialized equipment will keep track of the maturing of farm crops over enormous tracts, detect waterlogging of plantings, forest tracts, discover areas affected by insects on time, and they will keep track of pasturage, predict forage reserves thereon, and so on.

Specialists in agriculture find it vital to know the water resources of the immense territory of our Homeland.

Snow and ice covers on mountains and valleys can be clearly discerned on photographs taken from space. With these photographs one can determine reserves of water concentrated in the mountains. And this in turn enables proper organization of the system of irrigating farmlands in valleys throughout the entire growing season. It is just as important to know the process of thawing of snow and ice cover and the condition of mountain lakes. This permits timely warning of the population concerning menacing /177
natural disasters such as floods and eroding torrents.

Analysis of photographs and observations will help in establishing the regions of emergence of subterranean water onto the surface (in the photographs the moist region of soil differs from the dry by its dark shading), salinizing of soils and soil erosion.

People have experienced so much grief from hurricanes and droughts, fierce frosts and intolerable flooding that it has been long their cherished dream to find the keys to the secrets of winds and tides, snowfall and rain clouds. A confirmation of this is an ancient Indian manuscript that has come down to us -- a kind of instruction for farmers. It collects recommendations on how to observe the weather, in what seasons to plan and to harvest. Even then, about 2000 years ago, man tried to predict weather changes in order to be forewarned of possible tricks in the elements.

Information obtained from space observers will promote an increase in harvest yields, improve the quality of farm crops, expand arable lands, and reduce harvest losses.

Here is just one example. We know that during hot periods, at elevated temperatures, several days (within the span of a week) after the beginning of the ear formation in cereals, the conditions of pollination deteriorate and ultimately harvest yield decreases. From the space laboratory one can determine with special instruments the regions of commencing ear formation of cereals while simultaneously monitoring the temperature of these regions. And this will make it possible to give exact predictions of harvest yields.

Space laboratories will perform no less important a service also in the exact recording of land tracts suitable for farm use, that is, in cataloguing soils.

In a word, the potentialities of the use of orbital laboratories in studying this kind of natural resources are too diverse to be listed here in full.

As for economic advantage, this can be judged already just by the following fact: with an improvement in the accuracy of forecasting river runoffs in the period from April through August of one percent, one Canadian hydroelectric power station of mod- 178
erate capacity will achieve a savings of one million dollars.

The continuous scanning from space, photography, and interpretation of photographs will make it possible to keep track of tremendous areas of forests, compile their detailed maps, help in determining forest areas (measuring sectors and determining their contours) occupied by coniferous and deciduous trees, reveal age structure under the consition of growth of forest stands and

also assist in determining the regions infested by insects, observe consequences of human activities, especially in areas of tree-felling, evaluate the runoff of water over large areas of forests, and analyze the water-regulatory role of forests and the role of plant cover in combatting soil erosion.

Study of forests from space will make it possible to better understand the regularities governing the life of forests, to conduct forest-engineering operations, and to make timely forecasts.

A forest is often called the green treasure of the Earth. And this is actually so: one-fifth of the forested areas of the planet, a third of all wood reserves, and three-fifths of the world's reserves of the most valuable, coniferous wood are in our country. The area of the country's forest stock represents 10 million square kilometers -- half the territory of the Soviet Union. The species composition of our forest is highly diverse. Our duty is to rationally husband this treasure and make the best use of it.

How important the timely detecting of forest fires and the organization of forest-fire fighting efforts is can be seen in the scale of the possible calamities. In some dry years fire devastates areas of hundreds of thousands of hectares. A fire burns, wild animals and birds perish, soil hydrology worsens, and an entire series of sectors of the national economy is afflicted.

Regular patrolling of forests by orbital patrols over such an enormous country will make it possible to set up a system of observation for the breakout and spread of forest fires in the most remote and inaccessible regions. From space altitudes enormous forest tracts are observed simultaneously and with the aid of special equipment or simply visually one can determine, with high accuracy, the coordinates of the centers of forest fires and directly communicate them to the ground. I have already given specific examples. /179

Automatic space stations and orbital laboratories can successfully act as patrols in conservation, inform ground stations of the migrations of hordes of locusts and other pests of fields and forests, and report on time of the pernicious effects of industrial discharges on nature. Recently, for example, newspapers reported that an automatic U.S. satellite "exposed" an industrialist who had built a secret pipeline and through it was discharging harmful industrial wastes into a river...

Space photographs are even now helping to solve numerous problems of national-economic significance. Further detailed study of the technique of interpreting and processing photographs taken from spacecraft will help in making more exact estimates of

the natural resources of geographical regions and of our planet as a whole. The study of our planet from space will year by year play an increasing role in resolving national-economic problems. Even today it is difficult to name all the sciences and sectors of the national economy which will gain benefit thereby.

Here is yet another example: astronomy. Astronomers have long since tried to remove the telescopes beyond the Earth's atmosphere, which interferes with observations of stars, planets, and other space objects.

Astronomical instruments were lifted to space altitudes for the first time on the Kosmos-166 and Kosmos-230 satellites. But these were automatic systems. A manned orbital station equipped with various astronomical instruments is a dream of scientists studying the secrets of the skies.

Using instruments removed far beyond the bounds of the Earth's atmosphere, for example, one can conduct observations in the ultraviolet region of the solar spectrum inaccessible to ground-based astronomers, and study the spectral lines of the solar corona and chromosphere generated over a wide temperature range from tens to millions of degrees. From orbit it would perhaps be possible to trace how the condition of plasma jets and clouds changes as they pass from the chromosphere into the corona and from the corona into the chromosphere. From an orbital research station one could perhaps more swiftly determine the beginning of solar flares and track their development. /180

Study of solar corpuscular fluxes and their variations is very significant. The practical utility of this work is that scientists link magnetic storms, earthquakes, hurricanes, and other threatening elemental phenomena which, possibly, can be predicted, with solar processes.

Interesting observations of the Sun were conducted from the Salyut orbital station. The crew of the American Skylab station tracked the growth of several intense solar flares.

Physicists have also dreamed of penetrating into space. Their argument is persuasive: there they can significantly deepen and broaden our knowledge of presently known laws and phenomena, discover new regularities, and determine their place in the overall pattern of the structure and evolution of the universe, and gather from nature certain secrets known only to her. Today physicists need experiments in conditions that are lacking on Earth in order to extend theoretical physics, and the artificial reproduction of these conditions of virtually impossible.

Take supervacuum. The most powerful pumps in Earth laboratories are unable even in a small volume to produce a vacuum like the deep vacuum that space so lavishly offers us.

People learn to build on Earth powerful charged particle accelerators. Their energy is high. But in space it is possible to record such particle "phenomena" whose energy is millions of times greater than the energy given to charged particles by the most powerful accelerators.

We also note that the Earth's atmosphere is a kind of filter, which from the standpoint of various kinds of radiation passing through it is equivalent to a layer of water 10 meters thick.

It has been calculated that a particle with an energy of 10^{18} electron volts strikes one square meter of the Earth's surface on the average once every two thousand years. But in space /181
one can literally "swim" in a flux of particles at these high energies!

If we were able to accelerate to the speed of a space particle a steel sphere weighing only a gram, then on falling into the center of the Caspian Sea it would heat up the water to boiling point. In fact this is the energy of 10^{18} electron volts!

Space is a most unique physics laboratory. Only in space can one observe for lengthy periods the motion of quanta of light whose age is of the order of hundreds of billions of years.

Only in space can one encounter clumps of plasma matter with magnetic and electric fields "frozen" in it.

Only in space can one resolve many problems of cosmogony and especially those associated with the Earth and growth of stars and galaxies. Only in space...

Incidentally, this is enough... Great secrets of nature are stored there, in the austere mute world of the stars. On learning this, people can create miracles on Earth.

Space promises physicists the opportunity of studying the nature of gravity, of setting up experiments to test the theory of relativity, and experiments in magnetic hydrodynamics. (Indidentally, during just the first ten days in an orbit of one of the geophysical satellites more information on the Earth's magnetic field was obtained than over the past 100 years.) In orbital laboratories, physicists can search for hypothetical particles with fractional charge -- quarks, whose discovery would be extremely important for the modern theory of the structure of matter...

Physicists are also interested in the Sun -- this gigantic thermonuclear reactor. The study of its condition brings noticeably closer the age of the use of thermonuclear energy on our Earth.

The examples given above confirm that the role of astronautics in the fate of Earth creatures, in the destiny of scientific-technical progress is immeasurably more serious than may appear at first glance.

Yes, physicists have numerous problems and tasks. And they can be solved onboard orbital laboratories.

Well then, what can we expect from space in actual practice? /182 Casting and blowing of glass are two of the most ancient crafts on Earth. Molten materials in weightlessness take on the shape of an ideal sphere. Here surface tension that forms a thin layer of molecules is the shaping factor. By introducing gas inside a molten metal, a hollow sphere can be produced. One can expect that in the future entire enterprises will spring up in space. Space technology will lay the basis for manufacturing ball bearings of high precision and strength with different wall thicknesses and made of different metal combinations. From glass large lenses and mirrors of high quality can be manufactured in the "space plants." And in fact astronomers are very much in need of them!

It can be expected that in the future metallurgists and techologists can make steel or metal alloys capable of being retained in water like a cork, produce the most unique kind of foam materials... on board orbital metallurgical laboratory-plants. One of the most interesting prospects is in crystal formation. Metals with yield strength at least tens of times higher than the strongest alloys known to us today can be produced in space. And in a world without gravity, from these alloys such enormous tools can be fabricated of which scientists and designers on Earth have not even dreamed!

One cannot live only for the present, one cannot be concerned only with what will yield practical advantage right away or at least very soon. When you think about the events of past years, you are struck by the question: what does tomorrow hold for us?

It is not precluded that the setting up of space production facilities and transportation links between Earth and orbital enterprises can prove to be cheaper in some cases than further development of the counterpart lines of production on Earth.

Recall that K.E. Tsiolkovskiy wrote: "... Nearly all the Sun's energy at the present comes to us free for mankind... What is strange about the idea of using this energy!"

Further comments of scientists persuaded that one should not neglect the gifts of nature that technology will be able to use. /183

Semiconductor devices of solar batteries have already found a place on stations outside the Earth. They take from the Sun energy needed for the life and work of crews on spacecraft and space stations.

In appearing at a commemorative meeting on the occasion of the tenth anniversary of man's first flight into space, M.V. Keldysh, President of the USSR Academy of Sciences, said that plans are being formulated to us orbital stations in the future as major power systems transforming solar energy and transmitting it to Earth in the form of intense radiation. On Earth this radiation will then be again transformed into electrical energy.

Scientists of many countries are now discussing the question of setting up an enormous space reflector-mirror in Earth orbit. It will become a kind of "artificial Sun." The simplest of the versions provides for inserting into orbit in folded form extremely thin synthetic film with special coating. Gas released from cylinders will deploy the film, giving it the shape of a round mirror. On Earth, or on command from a dispatcher orbital station the space mirror can be positioned as required and direct the flux of solar light to any part of the Earth's surface.

Scientists calculate that this mirror with an area of one square kilometer in an orbit 36,000 kilometers in height will send to Earth a light spot 350 kilometers in diameter, that is, provide light for an entire oblast!

Orbital stations can be used for assembly of interplanetary space stations. The "stations" in space can also become unique moorings for long-flight rockets. The availability of these assembly and fueling stations outside the Earth and the possibility of linking up spacecraft with each other will enable us to use higher orbits and to push further the limits of space navigation.

Orbital stations can be used for training cosmonauts who will fly to other planets of our solar system and be in space a number of years. These flights are energetically advantageous not when performed from Earth, but from near-Earth stations. Naturally, /184 station on which spacecraft are to be assembled must be of considerable size and provided with variety of equipment. Cosmonauts, fuel, and all spacecraft parts will be delivered to the near-Earth stations via special transport rockets.

These stations will also have other major advantages. They will not be subject to such climatic effects as storms, snow, or fog. They will not depend on the Earth's rotation. In addition, beyond the atmosphere the possibility of using lasers for further

space communications are practically unlimited, while the use of lasers by ground stations encounters many difficulties due to the scattering of the laser beam in the atmosphere.

Man's participation in the scientific programs onboard an orbital laboratory will then ensure an important advantage such as the conscious choice of the objects of investigations. Given all the advantages of automation and remote control accessible in our present day, man's brain remains the most reliable "programming device" from the standpoint of rapid logical analysis of a situation and decision-making on the course of any particular experiment.

Man's presence in the space laboratory will make it possible to much more reliably monitor the performance of vital equipment, test new instruments, adjust systems, and supplement data obtained by instruments by visual observations.

Our Earth is beautiful. Yuriy Gagarin called it the blue planet. But it is important to note that our Earth, with all its amazing diversity, is studied by no means just to love it. Yes, it is beautiful, and the incomparable views from the windows of the Vostok, Voskhod, and Soyuz craft confirm this. But admiration arises from another fact: what exceptional opportunities laboratories beyond the Earth open up to us.

* * *

However, I have been carried away by dreams about the future of spacecraft and laboratories. Let me return now to our Soyuz-9 spacecraft.

Once a week according to the program we had "a day off," that /185
is, a day less scheduled with experiments, research work, and dynamic operations, which we used for active rest.

"Our days off" in space of course were not at all what they are on Earth.

On Earth after a heavy work week very many city residents go out into the depths of mother nature in order to rest and recuperate their energies. On one's day off it is a good thing to stroll through a forest, picking mushrooms, berries, and flowers. It is pleasant to hear the hum of forest life, the singing of forest birds, and it is enjoyable to sit by a stream fishing pole in hand.

On our days off on Earth, we often set out into the forest or to a forest lake, the three of us. Alena carried brushwood and built up a bonfire, while Valentina was busy preparing something

tasty. I really love to stroll with my daughter through the forest and answer her thousand "whys?"!

Of course, in space you can only dream of this, but nonetheless one of our artist friends once depicted us on top of the Soyuz-9 in trusswork sunbathing and playing chess. What can I say about this? Of course the artist invented the trusswork and the sunbathing on the "roof" of the ship.

But actually we did play chess.

On one of our days off on the 141st orbit, Colonel General of Aviation Nikolay Petrovich Kamanin suggested that we play a game of chess. He in fact gave us his suggestions as to the sides. For the Earth side he decided to play himself with pilot-cosmonaut of the USSR Viktor Vasil'yevich Gorbatko, and he suggested that the space side be made up of Vitaliy Ivanovich and myself, and for the duties of main umpire, second umpire, and operator, he requested pilot-cosmonaut of the USSR Valeriy Fedorovich Bykovskiy. We were very happy with their suggestion.

We knew that Kamanin and Gorbatko are strong chess players. While still on Earth, during our hours of leisure we more than once had interesting games with them. Knowing that ahead of us was a tough game, we agreed quite satisfactorily with the ground's suggestions.

We took with us into space a specially designed chessboard /186 that enabled us to play chess in weightlessness.

Using ordinary chess pieces for this purpose, even portable magnetic chess pieces, is not possible since there is always the chance of losing a piece when the pieces are being rearranged, during a game, or during storage after being removed from the board.

Our chess pieces were designed with awareness of the features of space flight. The basis of their design was two fundamental requirements: the object must serve its main function -- to give a graphic representation of the game situation on the chess field and completely avoid any chance of losing the pieces. Both these requirements were met in the chess pieces used in space by employing special devices on the board and in each piece. The board was equipped with a ramified system of grooves, and each piece had a coupling and locking assembly.

It should be noted that the initial inconvenience associated in the freedom of movement of the chess pieces gradually lessened during the course of the game and after a while they were no longer noted at all.

Before beginning the game we comfortably settled into our work seats in the command module, secured ourselves with restraint straps and set up our chess pieces.

On turning the chessboard, we accurately positioned the figures on it. In weightlessness, without securing the board it is impossible to play, since even a light touch of a finger against the board can cause it to float off and hang in space. Therefore we had to hold it with our hands all the while.

We reported our readiness to play to our umpire Valeriy Fedorovich. Ground offered us the first move, and we took it -- our first space move -- 1.d4. Ground replied -- d5. Thus, our game got under way. The following moves were made during this orbit: 2.c4 dc 3 e3 35. 4. C:c4 ed. 5. ed Kc6. 6. Ce3 Cd6. 7. Kc3...

Ground faltered while on the seventh move, and I jokingly reminded it that while they were thinking we had covered nearly a thousand kilometers. "They still have a whole minute left," /187
our umpire Vitaliy Bykovskiy defended the earthlings. "You can make moves faster on Earth, but we are flying beyond radio visibility..." paried Vitaliy. "7...Kf6," at once came the answer from ground.

Time passed rapidly during the flight and in 15-17 min we flew over our enormous territory from the western borders to the Pacific coast. During this time ground and we succeeded in making only five to seven moves. Our craft went beyond the radio visibility zone, we began to think about our next move and analyze the supposed move of our partners. Time flew rapidly, and on circling the globe, we again entered the communication zone. The game continued.

However, at first, on outpacing our chess players, Aleksey Leonov broke in to communicate to us:

"Falcon! I am Diamond. How do you feel? We are anxious for you. Will you play or will you wait? Acknowledge!"

"We are ready to play," Vitaliy modestly answered.

"Falcons, remember that we have many advisers here on Earth," Viktor Gorbatko broke into our conversation. "We can even win!"

"No matter, we will try. And we will find advisers here, in fact on board, you can say, we even have the Almighty..."

But here our little jokes were interrupted by the serious tone of the match umpire: "Time!" And we made our next move: 8. Kf3. Ground replied with a castling (0-0). We then castled: 9.0-0. Ground replied: Cg4.

I will not describe the entire course of our battle. It was hard-fought. Strong moves followed each other, on both sides. There were also blunders. On the 38th move (during this time we had flown more than a quarter of a million kilometers!), at ground's suggestion the match was ended in a draw. Of course, we felt like winning, but if you consider that the conditions in space are somewhat more complicated than on Earth, then a draw for us was a good outcome.

And this is what international grand master David Bronshteyn said: "We know that cosmonauts love chess a lot, and we waited impatiently as to who would make the first space move on the chessboard, and finally this move was made. From the depths of my heart I congratulate the participants in history's first space match and wish you a successful flight and a soft landing, chess players Andrian Nikolayev and Vitaliy Sevast'yanov." /188

This game, like everything in space, was not only a recreation, not only a diversion, but also a regulator experiment.

Our physicians kept track of our game with high interest; our emotional tension, our sense of well-being.

And this is how our condition was commented on during the game by one of the space medical specialists: "The flight program of Soyuz-9 provides for alternating work and rest, the optimal regime. A game of chess, as we know, is an active kind of recreation. It tones up the central nervous system and produces a position reaction. In addition, this is a change of activity, which is very useful for persons engaged in strenuous labor, especially such complicated labor as a space flight.

"Emotional attitudes are enormously important for success in the flight program. That is why serious attention is given to this aspect of cosmonaut work and recreation.

"The results of the chess game from the medical standpoint will be an object of special analysis. But overall the medical group evaluates the condition of the cosmonauts as good, and the work capacity is high."

On the 252nd orbit, the Chairman of the State Commission on the execution of our flight warmly congratulated us on setting a new record in flight time and wished us further success. We received congratulations both from the Chief Designer, from Colonel General of Aviation N.P. Kamanin and from all our comrades and friends at Central Flight Control Station.

Vitaliy and I cordially thanked all for their warm congratulations and their wishes of success.

We reported to the Chairman of the State Commission and to the Chief Designer that the flight program was being successfully carried out, that everything was shipshape on board, and that we felt good and our attitudes were good.

We reported that, from our calculations, there was enough oxygen for 23 days and we had enough water and food to extend the /189
flight. Vitaliy and I then requested permission to fly another couple of days. But ground did not support our request. The State Commission decided: we would operate exactly under the program, that is, we would land at the end of the 18 days of flight, on the 287th orbit. And this decision was transmitted to us by Dawn.

On the same day, Dawn transmitted to us a congratulatory radiogram from American colleague astronauts, Colonel Frank Borman and James S. Lovell, who completed a 14-day flight in Earth orbit in 1965 on Gemini-7. The telegram read as follows:

"We congratulate you and send you our best wishes at a time when you are setting new records in space research. Your achievements are an additional proof that man can live and work in space for lengthy periods. We wish you further success in performance of your important flight and your safe return to Earth."

Of course, it was pleasant for us to receive these congratulations. We asked Dawn to transmit to the American astronauts our cordial thanks for their warm congratulations.

The 18th day of the flight began. The flight program was fully completed by the 274th orbit.

Vitaliy wrote the following in large letters in his logbook: "18th DAY OF FLIGHT; HOME SOON!!!" I recorded this moment on motion picture film. Of course, it did not turn out as contrasty because he wrote with a blue Flowmaster pen, this color as we know does not turn out well in color film.

We felt elated. Just the word "home" inspired us. We had already begun to long for home, for our relatives and friends, for nature and the blessings of Earth. And the closer the hour of descent from orbit neared, the more strongly we felt the closeness of Earth, the more joyous our attitude. But ahead of us there was still much concern.

On the 275th orbit we underwent our final medical monitoring. /190
We performed our physical exercises for the last time and we began stowing our numerous scientific pieces of equipment. There were about 60 kinds of equipment just on the regular check list.

In a special soft cartridge case we placed the exposed cartridges of photographic film, the spectrograph films, the recorded magnetic recording tapes, the entry cards, and sheets of our experiments and tests, capsules containing test seeds, a set of burettes with collections of spacecraft cabin air samples taken at different flight periods, our heat-protective suits, the onboard star globe, and other equipment that was to be returned to Earth.

We transferred the loaded cartridge case into the command module, and placed it and securely attached it to the spare seat (to the left of the central seat).

In addition, in a separate bag we placed the pennants of the Central Committee of the Komsomol, the pennants with the embroidered Komsomol emblems belonging to the airfield Komsomol members. Here also we packed the membership books, photographs, postcards, and dolls of our daughters and the souvenirs of the flight: safety razors that we had used in shaving, pens and pencils that we had written our entries with, and our space chess set. And this bag we also placed on the spare seat.

We collected all our flight documentation in the command module in a specially assigned place. There was quite a great deal of material to be returned, all told. And all was placed and securely stowed in their proper places and in accordance with the design centering of the command module.

All the rest: the still and motion picture cameras, the replaceable lenses, spectrophotometer, medical instruments, accessories for physical exercises, vessels for collection moisture condensate and the other scientific-technical equipment were accurately stowed and secured in the orbital module.

On completing all this preparatory work, on the 277th orbit, before bed, we sat down to supper with big appetites.

On the 278th orbit, on passing the Kosmonavt Vladimir Komarov diesel motor ship, we cordially congratulated the crew and participants of the expedition for their good work and wished them success, health, and happiness. And they mutually wished us successful flight completion and a soft landing. /191

On the 278th-283rd orbits, the agenda of the day was sleep in the orbital module. We rested well. Our condition and attitude was excellent in the "morning."

On the day of the landing, 19 June, on the 283rd orbit, we awoke at 8:00 in the morning. And at once we began the final check of the readiness of all our facilities and systems for the descent.

At 12:55 we switched on the angular rate sensor and the manual orientation. Using the control knob I oriented the ship toward Earth and turned it in the flight direction -- "for landing," that is, with descent engines facing forward in the line of travel of the craft.

At the schedule time, at 13:08:40, the automatic "descent one" program was switched on. During the first minutes of operation of the descent program, the programmer was adjusted. All was normal, as planned.

And now we entered our 286th orbit.

"Falcon, I am Dawn 16, we send you meteorological conditions in your landing area:

"cloud cover cumulus, scale degrees five-seven;

"cloud base altitude 1500 meters;

"visibility 12-16 kilometers;

"wind near ground 5-6 meters per second with gusts to 8 meters per second."

We answered that all was understood.

"We are awaiting your detailed information as to time of descent. Use all radio communication channels for the information."

"Read you, I am Falcon."

"After landing, don't hurry. Examine your instructions. You have time and you can act according to instructions. Avoid abrupt movements. How do you read me, I am Sixteen?"

"We read you -- avoid abrupt motions and act according to instructions. All will be done."

"We wish you a soft landing, we await you on Earth."

"Thank you, thank you, I am Falcon." /192

"Falcon, I am Dawn. How is the manual orientation of the ship proceeding? Normally?"

"Yes, ship orientation is proceeding normally. We actually were able to complete manual orientation before switching on the program. Everything is normal here."

"Everything down here is also excellent. The weather is splendid. You probably can see everything from up there."

"Yes, everything is clear."

"On Earth the sky is clear, the wind is very gentle."

"We read you."

"We will record everything you say on short-wave and ultra-short-wave stations, because during the descent section you will try to send us the information on all channels. Any observations, any information will be very much appreciated by us."

"Clear, we read you, I am Falcon."

"Everyone is following you closely, so we are waiting for your every word."

"We read you."

"It's not boring to you there?"

"No, we have gotten used to it now. We can't get bored."

"Everyone is ready to greet you."

"Everything on board is shipshape. Everything here is going as scheduled."

"Keep an eye out during your descent whether you have flames or not."

"We will observe."

"Don't forget to leave your tape recorder on. And record all the information during your descent. You have enough tapes for the entire descent and after the landing."

"We read you, we will place the tape recorder on continuous record."

"We read you, I am Dawn. We hear you weakly. End of transmission."

"We read you, I am Falcon."

On departing the communications zone, we continued to monitor the performance of the program of the automatic landing system "descent one." All ship systems were operating smoothly. From the programmer, commands were coming clearly and being performed on time. Everything was fully in order on board.

The 286th orbit was coming to a close and the time for /193
cutting in the retro engine was fast approaching.

We passed the shadow side of the Earth. We observed the last space dawn, the last sunset, and the remarkable solar halo. We emerged on the sunlit side of the Earth.

We checked the craft's orientation. It was exact, on a landing bearing: the Earth rushed up from beneath us on the screen of the display. The landing engine was cut in by the programmer as we flew, south of the equator, short of the coasts of Africa, over the Atlantic Ocean exactly at the scheduled time, at 14:17:30. It performed stably, with the characteristic roar accustomed to us, like the sound of a primus stove. During its burn we sensed the still noticeable, but very pleasant g-load.

During this time the sensation was as if we were being carried upward, upward at an angle of about 30 degrees. After firing the set time, 145 seconds, the engine cut out. The cutting in of the engine and its burn time was reported to the vessel maintaining communications with us. She confirmed the reception of our reports and wished us a soft landing. We warmly thanked her for her good wishes.

Ahead on the program there was to be the separation of the command module from the instrument-unit and orbital modules. We had prepared fully for this critical operation: we settled down more comfortably into our work seats and tightened our restraint straps. Exactly at the set time separation occurred. Through the cabin windows we could see the instrument-unit and orbital modules separating from the ship. On the instrument panel there glowed the "separation" and "ALS" (automatic landing system) transparencies; manually, we duplicated the cutting in of the ALS. We reported to Earth on ship separation and on the triggering of the automatic landing system.

In order to reduce the effect of g-loads on the cosmonauts during descent and to increase the accuracy of craft landing at the designated point, Soyuz spacecraft made use of their aerodynamic qualities. To regulate the lift on the craft in accordance with the trajectory of deorbiting, an automatic control descent system was installed. From the moment of separation, by utilizing special vernier jet engines located on the hull of the command modules, it controlled the position of the ship in space /194 along the channels of pitch, heading, and roll.

After separation, the ship's angular rates were rapidly damped. Then the ship performed the programmed turn in pitching and rolling. The controlled descent system operated smoothly. We could clearly hear the triggering of the channels for the burns of the jet engines. Through a window we could visually observe the turning of the ship with respect to all three axes.

We gradually descended. Beneath us passed sandy deserts and the oases of Africa. And here, the Mediterranean Sea. Finally

we saw the Black Sea, and we felt fine. We were going to Earth, to home!

At an altitude of about 100 kilometers the highly rarefied atmosphere begins. On attaining a g-load of 0.04 units the "atmosphere" transparency "glowed." The controlled descent automatic unit, on determining this g-load recorded the reference curve of g-loads. By comparing the assigned g-load curve with the existing curve, it determined the trajectory of the further descent in order for the landing to be at the scheduled point. Here the automatic device, on changing the roll, regulated the lift of the ship and thus maintained the chosen g-load curve. The flight range and landing point of the ship were regulated.

As the craft descended into the dense atmospheric layers, the g-loads gradually built up. The ship proceeded stably, and the ship turns and vibrations were slight.

We reported all to Dawn.

"Dawn, we are passing over the southern part of the Caspian Sea, we see it from our right window. Separation went normally."

"Falcon, I am Dawn, we hear you we read you."

"Dawn, I am Falcon, we hear you fine. We repeat our messages. Separation went normally. Descent is excellent. The engine fired for the set time -- 145 seconds. Everything is going according to the flight program."

"We understand you, I am Dawn. According to our data, you're going fine, fine."

"The cutting in of the automatic landing system was duplicated, and the cooling-drying unit, drier, and ventilator of the command module have been turned off."

"We read you, I am Dawn." /195

"Now we are turning along our roll axis. The ship is moving stably. The g-loads are gradually building up. They are not yet strong."

"We read you, Falcon; keep sending us all your observations."

"We read you."

"Is your tape recorder on?"

"Yes, it's on. We are recording everything."

At this moment we stopped hearing Dawn. But we kept delivering our reports on the descent up to our very landing.

With further descent, the ship began to tremble somewhat, but there was no strong jarring and shaking, as on the Vostok.

Yellow, and then orange soot began appearing on the outer glass of the right window. To some extent this reduced the transparency of the window, however it did not interfere with the observations and through it we could clearly scan the locale we were overflying.

Past the windows there began to stream a series of diffuse, glowing particles, fragments similar to tracer bullets. Then ionized plasma in the form of a barely noticeable flame appeared beyond the windows. This flame was completely different from what we had seen on the Vostok. On entering the dense atmospheric layers there was a sensation on Vostok-3 as if you were sitting in a boiler, with flame all around. But here the flame was barely noticeable.

During the descent at first we could hear a weak noise, a high-tone whistle. This tone gradually built up and was converted into the hum of the firing jet engine, and then it changed as if occurring during the supercharging mode of an aircraft engine with a powerful roar.

The ship kept moving stably. The g-loads gradually built up. However, based on subjective sensations their magnitude did not exceed 3-4 units. Then we sensed a series of continuous jolts, whose frequency kept diminishing as the ship slowed down. But after passing the zone of maximum g-load and maximum thermal flux, the jolts faded away and we sensed only slight vibrations of the craft. /196

Throughout the descent section we observed the overflown locale through the cabin windows. Beyond the Caspian Sea the Aral Sea appeared beneath us, then there swam by small lakes, rivers, steppes, plowed fields, and inhabited points. In places there were cloud covers. The closer we approached the Earth, the more clearly we could see the overflown locale.

In the Earth's atmosphere, before the landing of the craft, the shroud of the main parachute container was jettisoned by command from the automatic landing system. Then the drogue chute deployed. It pulled from the container the braking parachute, designed to slow the craft velocity so that the main large-area parachute could open up. When the drogue, braking, and main parachutes had opened, the g-loads were minor. They were sensed in weak jerks. After the parachute opened up completely, our ship as it were hung in air and began rocking gently. Our condition and attitudes were excellent.

Rigid requirements were imposed on the ship's parachute system. The entire system had to be of small weight and volume and strong and reliable in operation. The dome of the parachute itself had to withstand heavy loads. So the quality of the parachute dome paneling was vital. Chemists and specialists in fabrics worked to formulate strong fibers and cloth. They made remarkable materials for the manufacture of spacecraft parachute systems. In the event the main parachute tore or failed to open, the entire system was ejected and at once the reserve parachute system opened up.

On command from the automatic landing system the front heat-protective shield was jettisoned, retensioning to symmetric suspension of the parachute occurred, and the seat shock absorbers were smoothly suspended. The seats were lifted and occupied their working position. The seat shock absorbers were designed to soften the g-loads in the event that the soft landing engines failed to fire before the actual touchdown of the craft.

All the ships systems were fully prepared for the landing. The breathing valve was opened. The cabin was filled as if with steam, and at once we sensed the aroma of fresh air. The atmospheric pressure in the cabin was equalized with the ambient environment. /197

Earth came closer and closer. The lower edge of the cloud cover appeared. The airplane and helicopter from the search team that had come around us could be seen through the cabin windows. Beneath us there was a small lake. We thought about how much fun we could have at the lake, but the distance to Earth was still considerable. We passed smoothly across the lake and beneath us again there was level land. There was just a little distance remaining between us and the ground, and beneath us there was a plowed field, and about 200 meters away -- a tractor.

We clearly reported all to Dawn. These reports were recorded on the tape recorder. Before the actual touchdown of the ship, at an altitude of 40-50 meters we adopted a convenient position in our seats and tightened our restraint straps and began awaiting the touchdown.

The soft landing engines were triggered, the ship began to touch down in the middle of the freshly plowed strip, 15 meters wide. We settled down in the scheduled area in the Sovkhoz imeni Chkalov, 75 kilometers from Karaganda. It was 19 June 1970, 14:59 Moscow time.

After touchdown and rocking left and right, the ship remained vertical. On being convinced that the ship was stable, we jettisoned the strand arrangement -- the suspension of the parachute provided to fully collapse it.

Thus, we were back on Earth. We had ended our 18-day flight. We heartily congratulated each other on our return to Earth.

PART 3. BACK TO EARTH /198

Almost simultaneously with our craft, a helicopter touched down roughly 30 m from us, and several minutes later specialists from the search team appeared by the craft windows. We showed them thumbs up. This meant that everything was normal in the ship. They understood our signal and smiles broke out on their anxious faces. Now they began to open the ship's hatchway from the outside. The fresh aromatic air of Kazakh soil wafted in. Through a crack formed between the passageway hatch and the hull of the ship chernozem soil slid down on me, the soil covering the cover of the hatch during the firing time of the soft landing engines. I held the cover down and asked the specialists to clear it of earth. Finally the hatchway was opened.

We freed ourselves from our chests, waist, and knee restraints. During this operation we at once felt that this was Earth's gravity. It was difficult to rise from our seats and to assume a vertical position. Our legs would not respond, they were like wadding and at the same time heavy as lead.

Then gradually I came to understand: why it is that it is hard for man to live on Earth! Every second of every minute, and during his entire life there acts on him the by no means abstract force of gravity.

With great effort I placed my legs on the recessed part of the seat. I pulled myself up by my hands, assumed a vertical position, and by thrusting myself out along my chest from the command module I saw our comrades -- fellow cosmonauts, engineers, physicians, and pilots. Alongside the ship there were Vladimir Shatalov, Aleksey Yeliseyev, athletics commissar Ivan Grigor'yevich Borisenko, and others. Somewhat to the side of them there stood arriving workers, kolkhozniks, shepherds, and tractor operators. And 200 m from us there stood a tractor on which you could plow a strip 50 m wide. In fact our ship had landed in the middle of this plot. Thirty meters from us stood the helicopter with rotating blades. /199

Our greeting comrades bore joyous smiles on their faces.

With a wave of the hand I greeted all who had come to meet us and at once reported to the leader of the search team that everything was normal with Vitaliy and myself, and asked that a report be sent via the helicopter radio to the Flight Control Center on the successful landing and that an obligatoryy confirmation of the receipt of this message be obtained.

Soon we were told from the helicopter that our request had been met. It was pleasant for me that our comrades at the main control center had received our report and had learned about our

successful completion of the prolonged space flight and that their anxiety had lessened.

I knew full well how right now everyone at the control center was congratulating each other on the successful completion of our flight.

I must admit that it was hard for me to be in a vertical position. Weakness set in and my pulse rate grew faster. I felt as if the blood was rushing from my head to my feet. A gray film began to appear before my eyes. I lowered myself, occupied my position in the seat, and at once felt much better there.

According to instructions, soon after landing we had to jettison the short wave and ultrashort wave communication antennas. And once more I had to raise myself to warn the people assembled around the ship to move further away. With great effort I crawled on my chest from the craft and told them that we will now jettison the radio antenna. On having said this, I at once returned to my seat and asked Vitaliy to jettison the radio antenna. And he asked: "Have the people moved away?" "I don't know, Vitaliy, I warned them to." It was difficult for me to lift myself up once again and check whether the people had moved away from the craft or not. Vitaliy pressed a button and the antenna was jettisoned. /200

Then we began to pile up and pass out through the hatchway to those who had come to meet us our logbooks, instructions, scientific equipment, motion picture film, souvenirs, and other material returned from the flight. All the objects felt very heavy. It was hard, for example, to lift the bulky 500-page logbook.

Vitaliy removed his helmet microphone, he let it slip from his hands, and it fell. Objects seemed heavy to us because the muscles of our hands and fingers had been accustomed to weightlessness during the flight, and in fact these very things: the helmet mike, the logbook, the still and motion picture cameras -- we held in our hands and moved from place to place in weightlessness with nearly no effort. But here, on Earth, at once on landing our muscles were still not adapted to the fact that everything had a weight.

Vitaliy was to the right of me in the working seat and was somewhat covered by the open hatchway. And therefore it was quite hot for him. He urged me to keep moving faster so that I could more rapidly finish passing out the objects we had brought back from the flight. I understood him well. He wanted to leave the ship as fast as possible. Our wishes coincided. But what could you do if there were so many things to be unloaded from the ship and passed out to those who had met us.

On passing out the last pack of cartridges with the scientific equipment, I pulled myself up by my hands and rose to my feet. I was helped to leave the ship and lower myself to the ground by the search team comrades.

After my exit, the comrades helped lift Vitaliy also out from the command module. Vitaliy at once scooped up the freshly plowed soil with both hands, brought it to his face and, breathing deeply, said: "Here it is, Andryusha, our soil! Hello, native land." I also rapturously breathed in its aroma.

We were surrounded by friends. They warmly congratulated us on the flight completion. They asked us we felt. We were happy, rejoiced, accepted their congratulations, and answered their questions. We were grateful to our friends and comrades who cared so much about us. The physicians at once took us into their "embrace." They began to take our pulse, measure our /201
blood pressure, ask us about how we felt, suggest that we drink water, but we did not want to drink. It was difficult to sit on the stretchers. My head, arms, my whole body was very heavy. I gain lay down and felt some relief. But laying down was also not becoming, it was inappropriate to display such weakness in front of the comrades and gathered people who were around us. They could think: what now, they've made their flight, and they cannot even sit down. This false shame spurred me and I again lifted myself. And so I changed my position several times as the physicians took their measurements. My pulse was 90-100 beats per minute, my systolic blood pressure was 130 mm Hg, while sitting, my pulse was 110-120 beats per minute, and by systolic blood pressure was 140 mm Hg. My cardiovascular system could not adapt to the conditions of Earth gravity.

Finally, the first examination ended and we turned over our spacecraft Soyuz-9 to the technical director of the search team.

Two cots had been readied for us in the helicopter. They placed us in them very snugly and comfortably. With us were our cosmonaut friends and our companions -- the physicians.

The helicopter lifted smoothly into the air and in 30 min had brought us to a landing pad alongside a little house which our great friends from Karaganda had graciously offered us. After completing a space flight cosmonauts were always put up there. For example, I was made happy more than once by staying in this cozy little house. They received Pavel Popovich and myself for the first time in August 1962. Here also I greeted our comrades from the space voyages. And now again the hospital Karaganda land and this lovely corner of Karaganda was greeting us.

There were many well-wishers on the pad and in the house. At once the question was asked: How did it go with us? It was

difficult for us to go by foot, and the same false shame came in the way of going by stretcher. Then it was decided to drive up a passenger car to the helicopter. Volodya Shatalov, Lesha Yeliseyev, and the physicians helped us exit the helicopter and be seated in the car.

They drove us right up to the entrance to the house. Again with the help of our comrades we got out of the car. We were held up by our friends. The well-wishers warmly greeted us. We /202
responded to their greetings, but we very much wished to reach the cots as quickly as possible. As I thought, Vitaliy wished the same. My body felt heavy. On climbing the stairs, we kept stumbling, and when I tried to jump up a stair my legs stayed in place -- I couldn't make the leap.

Physician Vladimir Alekseyevich questioned Vitaliy and me: how would you like to be accommodated, in one room or separate rooms? We answered him at the same time, in the same room.

They placed us in a comfortable room, we changed into clean linen and we stretched out on the beds. But we could not lay down for long. The doctors again took us in tow. They weighed us. During the flight I had lost 2.7 kg, while Vitaliy had lost 3.9 kg. In all probability our weight loss was due not only to the dehydration of our organisms, but also to the reduction in the volume of muscle and fat tissues.

(It should be noted that in contrast to other comrades who had flown, in our case weight recovery after the flight was more prolonged and was completed by the thirteenth day.)

The physicians noted significant statokinetic disorders -- instability upon standing, uncertainty and staggering while walking.

Other changes were also noted.

After the examination, while laying in bed I began to shave with an electric razor. It felt much heavier than usual. Then I took a warm bath. When I lowered myself into the water, I remember Archimedes' law -- at once the heaviness of my body disappeared. It was here that I sensed a truly blessed relief. I washed myself and I must say frankly that I had no desire to leave the water. But I could not stay forever in the bath. I had to crawl out, and again the Earth's gravity weighed down on me.

Roughly 3 hours after the landing, it was suggested to Vitaliy and myself that we walk along the corridor by ourselves to the cafeteria for a meal. When we set out, we staggered noticeably. It was good that the corridor was narrow. Our movement along the corridor was recorded on motion picture film. And today,

when we view these frames in Star City, our comrades joke over us: what then, after landing, did you really tie on a couple?

But at the time it was no joking matter to us. Any forward motion was accompanied by a quickening of our pulse rates, reddening of our faces, neuroemotional stress, and total concentration on control of our actions and the efforts we exerted. During walking our legs were placed broadly toward either side in order to keep our balance. When one leg was moved, the drunk rolled to the opposite supporting leg. Our heads were inclined forward and downward in order to visually control movement of the legs. Our hands involuntarily stretched out to the sides to keep our equilibrium. Our steps were short and unstable as to length. The walking was a kind of "stamping", without keeping a straight line of travel. /203

On moving ahead of myself, I will say that on the second day after landing walking improved considerably, and we were able to virtually recover our natural gait, and only a noticeable stamping of our feet on the ground remained.

However I got somewhat carried away. Let me return to the hotel.

At the entrance to the dining room we were met by the Secretary of the Karaganda Party Oblast Committee Vasiliy Kuz'mich, the Chairman of the Oblast Executive Committee Sultan Koparovich, and other city representatives. They greeted us on the successful completion of the 18-day space flight. Vasiliy Kuz'mich read to us a resolution on making us honorary citizens of the city of Karaganda. Then an enormous cottage loaf of wheat bread, miners hats, and for our daughters Alenka and Natasha -- dolls and candies -- were offered us. Vitaliy and I warmly thanked them for the high honor shown us, for the warm reception, and for the remarkably fragrant loaf of bread.

They brought us to the dining room, where already a table had been laid. In the middle was a large loaf of white fragrant bread. And alongside was chicken, aspic tongue, sausages, fish, fresh and slightly pickled cucumbers, tomatoes, cherries, sliced lemons, and fruit. During the flight we greatly missed real Earth food. So this table appeared to us as if in a dream. At the beginning of the meal a large chunk of fragrant wheat bread was broken from the loaf and we feasted on its aroma. Then we tried the cherries. However, I could not clearly determine whether this was a cherry or not, by tasting. Cherries usually have a sharp-sweet taste. What was in my mouth had nearly no taste. We were assured that these were actually cherries. The lemon also did not appear as sour as it was before the flight. Then we tried the remaining food, and all the dishes also had a somewhat altered taste. So it appeared to us that during the flight time our receptors determining the taste qualities of food had been blunted. /204

First we were offered borshch and chicken broth. Vitaliy preferred borshch and I -- the broth. Next they offered us tasty pel'meni. But the doctors recommended that we only ate six to eight, because pel'meni is a heavy food for the stomach. At the end of the meal strong fragrant tea was served. This concluded our first Earth meal. We warmly thanked the hosts for both the splendid meal as well as their hospitality. Although we ate with good appetite, it was still kind of hard for us to remain in a sitting position. You incline your head to one side, and the whole trunk is drawn after it. In order to keep yourself from further tipping over you have to apply a certain amount of force.

After the meal a short talk was held with the correspondents who had assembled behind the glass door of the dining room, while we remained behind the table, in our places. The glass door separated us. The doctors organized our meeting with the correspondents in this manner. They believed that our organism had weakened and could not withstand different kinds of infections. The meeting was short and limited to several questions and answers about the flight, about the landing, and about how we felt.

Even when we were still at the landing site we issued a statement to the press:

"To the Central Committee of the CPSU, the Presidium of the Supreme Council of the USSR, and the USSR Council of Ministers. We report that today, 19 June 1970, after the full completion of its program, the spacecraft Soyuz-9 completed its landing at the designed location of the Soviet Union. The crew of spacecraft Soyuz-9 was 18 days in orbital flight around the Earth.

"During the flight a complex program of scientific-technical experiments was carried out, a complex of medical-biological studies was performed, and new apparatus and units were tested in prolonged space flight. All spacecraft systems functioned normally. /205

"We warmly thank the Central Committee of the CPSU, the Presidium of the Supreme Council of the USSR and the Soviet government for the great trust placed on us in performing the extended flight.

"We feel fine. we are ready to perform new missions.

"Commander of spacecraft Soyuz-9, Colonal A.G. Nikolayev.

"Flight engineer of spacecraft Soyuz-9, Candidate of Technical Sciences V.I. Sevast'yanov."

Before the beginning of the press conference, we were given the warm congratulations of Leonid Il'ich Brezhnev on the successful completion of the program of the 18-day space flight and his kind wishes.

The fatherly concern and attention shown us by Leonid Il'ich was a great honor for us, and we were touched to our depths. We deeply rejoiced at this message and sensed a surge of energy and good spirits.

At 8:30 p.m. we were invited to the next room, where there was a telephone. Vitaliy and I were placed in touch with Moscow and spoke with our families. Valentina and Alena and Alevtina and Natasha congratulated us on completing our flight. There were many warm and heartfelt words on both sides. On reporting to them of the scheduled flight tomorrow to Moscow, we ended our conversation.

After the conversations our attitude was excellent, we were happy.

Before going to bed we took baths. And once again I sensed the agreeable lightness of my whole body. A great lightening set in. At 9:00 p.m. Vitaliy and I lay down to sleep. We feel asleep rapidly, since we were pretty well tired from the day. On sleeping 2 hours, that is, to 11:00 p.m., we both woke up at the same time. Vitaliy woke up because he wanted to eat, and I -- to drink.

In the hall there was a teapot with tea on the table (already cooled) and cherries -- in a bowl. For us nightbirds, there was nothing much to do except to drink the cold tea and eat up all /206
the cherries. After this we went out to the balcony. The night was very dark, silence was all around, a warm fresh breeze was blowing gently, there was not a cloud in the sky, and the constellations could be seen clearly. We stood out there, we drank in the night darkness and the twinkling stars, we remembered how they looked from outer space ...

Then we returned to our bedroom, we laid out on the beds, and for a long time we were unable to fall asleep. There was the sensation as if our bodies growing heavier and heavier were pressing down into the beds. I could feel all the springs of the bed. However I did not even want to fall asleep because at this time our agenda for the day was on the space schedule. Our sleep normalized only on about the fifth day.

During the g-loads on Earth I continually was thinking of how good it would be if suddenly again I could find myself in weightlessness and have a good sleep like a human being, to rest even a little from Earth's gravity that continually was pressing donw on us.

Vitaliy suffered just like me. When I told him what I was thinking about being in weightlessness in order to fall asleep and rest he agreed along with me. And even if this were possible, it would be best not even to have to wish about it.

Thus we talked together until three in the morning. We recalled space, we drew up our plans, we dreamed about the future ...

At 4:00 a.m., we arose. We washed ourselves, we had our medical inspection and then breakfast. It was now time to get underway on the road. On thanking and bidding farewell to our hospitable hosts, we got into the car. With us was the First Secretary of the Karaganda Oblast Committee, Vasiliy Kuz'mich, and the chairman of the Oblast Executive Committee, Sultan Koparovich. On the way to the airport we drove around the city. Vasiliy Kuz'mich, pointing out the city, spoke about what gains Karaganda had made in recent years. It was pleasant to see the new blocks of modern houses, stores, theaters, and well laid out streets. We rejoiced over the new gains achieved in city construction, industry, and agriculture. This was very interesting.

At the designated time we arrived at the airport. We thanked Vasiliy Kuz'mich and Sultan Koparovich for telling us about Karaganda, for their hospitality and, on bidding them goodbye, along with our comrades Vladimir and Aleksey we climbed the ramp and took our places in the plane. There were two beds prepared /207
for us in the aircraft passenger area. Vitaliy and I comfortably settled down into them. Winging up into the skies, our Ilyushka headed toward Moscow. While we were flying, I was able to get some sleep.

When our silver IL-18 air liner touched down and its engines stopped, the ramp was brought to the plane. I looked at my watch and saw that it read exactly 12 noon. We came out to the top landing of the ramp. To the left of me was Vladimir Shatalov, and alongside Vitaliy, Aleksey Yeliseyev. On making it down the last step of the ramp, beneath us was smooth concrete. Ahead was a group of persons coming to meet us. We took several steps on the concrete slabs toward the chairman and members of the State Committe. I reported to the chairman on the completion of the flight program and how we felt.

He warmly congratulated us, thanked us for the successful completion of this complex mission, and wished us good rest.

Among those greeting us was the Chief Designer, members of the State Commission, scientists and designers, fellow cosmonauts, Valentina with Alenka, and Alevtina with Natasha.

Vitaliy and I fell into the embraces of our dear ones and friends. The meeting with Alena and Valentina was the most

pleasant and joyous for me. Then together with families and physicians we got into cars and drove to Star City to the dispensary where beds had been prepared for us for resting and for medical examination.

On the road to Star City, Alena began to tell me everything new in her life: about how she had been waiting for her daddy, how bored she felt without him, what new toys the uncle cosmonauts had bought for her, and what books her mama had read to her. She spoke nonstop. And I listened to hear, forgetting about Earth's gravity.

The arrangements were very good in the dispensary, and we spoke some more with Valentina and Alena. They told me that everything was normal at home, that our grandmothers Anna Alekseyeva and Yelena Fedorovna felt fine, were happy, and sent us their greetings and congratulations. Our talk was short, since the physicians were now ready to examine us and were waiting for us to finish our meeting. I wished that I could listen on and on to Alena's flood of speech. And I had much to tell myself, /208 but the time slipped away. There had to be discipline here as well, on Earth! Valentina in fact understood this. We bade farewell to each other until tomorrow.

As soon as they left me, physicians at once began the examination. The medical examination schedule was set up separately each day, and today we were examined by specialists headed by Full Member of the Academy of Medical Sciences Professor Nikolai Semenovich Molchanov.

The results of their examinations were to be of vital importance in preparing crews for new extended space flights.

At 2:00 p.m. we were called to the telephone, with the message that we were to speak with Leonid Il'ich Brezhnev. I felt a kind of inward anxiety. Picking up the receiver I said:

"Colonel Nikolayev speaking."

"Andrian, is that you?" I heard the familiar voice of Leonid Il'ich in the receiver. This soft voice and warm simple language had an effect at once: my anxiety left, I felt easier.

"Yes, Leonid Il'ich, it is I, Colonel Andrian Nikolayev. I wish you health! I report to you, Leonid Il'ich, to the Central Committee of the Party, to the Supreme Soviet of the USSR, and the Soviet government that the assignment of the party and government has been fulfilled. The crew of spacecraft Soyuz-9 carried out all of the program of the 18-day space flight. All ship systems functioned clearly, without anything unusual. We feel normal."

"Hello, Andrian," I heard Leonid Il'ich's voice, "I congratulate you on the successful completion of the complex space flight. We thank you for having fully performed the mission assigned you."

"Thank you, Leonid Il'ich!" I answered. "Yesterday they gave us your congratulations and your warm words of best wishes. Vitaliy Ivanovich and I were touched by your attention. Many thanks, Leonid Il'ich!"

"How do you feel now?"

"Today, Leonid Il'ich, we feel better, but yesterday was somewhat hard," I frankly admitted. /209

"Try to improve a little faster, we will be meeting you in Moscow."

"Thank you, Leonid Il'ich."

"I hug you and kiss you, Andrian."

"Many thanks, Leonid Il'ich, for your attention and for the fatherly concern you have shown us."

"Is Vitaliy Sevast'yanov nearby? I would like to congratulate him."

"Vitaliy is right here alongside me. So long, Leonid Il'ich, I give the receiver to Sevast'yanov."

"Until we meet in Moscow, Andrian!"

"Until then, thank you, Leonid Il'ich."

And I passed the phone to Vitaliy.

To the talk with Leonid Il'ich, we had very good, joyous, and elated feeling, and we retold each other our talk with the General Secretary of the Party Committee at greater length.

The doctors again took us into their "embrace." They continued the medical examination according to the plan of this day: study of peripheral hemodynamics (blood circulation); study of neuromuscular apparatus; determination of stability of vertical posture; study of physiological tremor (trembling of the wrists); muscle tone, muscles of the knee, hip, and shoulder; determination of the total muscle contractibility with a standard load; measurements of the parameters of the extremities; estimate of force indicators; manual dynamometry (right and left), and exercise station strength; estimate of the condition of reflexive

excitability of the biopotentials of the muscles participating in the knee reflex (right and left).

Here, in the clinic, we had to undergo careful medical-biological examinations for a certain amount of time. Specialists wished to study the state of our health in greater detail.

However, by 6:00 p.m. they left us alone.

On being released from the examination and comfortably situated in our rooms, with great interest and attention we buried ourselves in reading the current newspapers.

With great attention we read the TASS report of 19 June 1970. I present it here in full:

PROGRAM COMPLETED /210

On 19 June 1970, at 2:59 p.m. Moscow time, after completing the extended flight program in Earth orbit, spacecraft Soyuz-9 touched down at its designated point in the Soviet Union, 75 km west of the city of Karaganda.

The cosmonauts, comrades Andriyan Grigor'yevich Nikolayev and Vitaliy Ivanovich Sevast'yanov felt fine on landing.

At the designated time craft orientation and firing of the retro rocket were performed for the descent to Earth.

On completion of engine firing, the craft modules separated and the command module with crew entered a flight trajectory toward Earth. The flight of the command module followed a trajectory of controlled descent using aerodynamic lift.

Cosmonauts A.G. Nikolayev and V.I. Sevast'yanov were warmly greeted at the landing site by representatives of the search team, sports commissars, friends, and journalists.

The operational and medical examination of the crew at the meeting point showed that the cosmonauts had well tolerated the prolonged space flight.

The prolonged space flight of spacecraft Soyuz-9 had come to an end.

The crew made up of Hero of the Soviet Union, cosmonaut-pilot of the USSR Colonal A.G. Nikolayev and Candidate of Technical Sciences V.I. Sevast'yanov fully performed the scheduled program of scientific-technical and medical-biological research.

And one more TASS report.

A NEW STEP ON THE PATH TO ORBITAL STATIONS

On 1 June 1970, spacecraft Soyuz-9 was inserted into artificial Earth satellite orbit in the Soviet Union....

On 19 June 1970, at 2:59 p.m. Moscow time after performing /211
the scheduled program of the 18-day flight, spacecraft Soyuz-9 landed at the designated place with high accuracy.

The crew of spacecraft Soyuz-9 had been in orbital flight around the Earth 424 hours. An experiment of this duration with active human participation in space flight conditions was the first of its kind ...

Yes, now this was all behind us. And besides, the flight itself and all of those 18 days of being away from Earth did not now appear to us to be too long. Rather, it felt as if it had all taken place in a flash ...

"... Numerous scientific-technical studies, observations, and experiments aimed at further study of near-Earth space and determining the possibilities of using orbital spacecraft in the interests of many sectors of the national economy.

"During the flight scientific observation and photography of individual represenative areas of the Earth's surface, geologically speaking, was carried out. In particular, photographs were taken in the European part of the USSR, Kazakhstan, and Western Siberia. At the same time with this space experiment, photographs were also taken from geological prospecting aircraft.

"During the flight of the cosmonauts, Nikolayev and Sevast'yanov observed and photographed the phases of the ascent and descent of the Sun and Moon, clouds and vapors, snow cover over the Earth, and various atmospheric phenomena to use the data for operational and long-term weather forecasting. Thus, the cosmonauts repeatedly reported on storm phenomena and cyclones. Information on forest fires, dust storms, and storms at sea were sent from the spacecraft to Earth.

"In the western part of the Indian Ocean, a unique experiment on photographing cloud formations was carried out; besides the Soyuz-9 spacecraft, the "Akademik Shirshov" research vessel of the /212
USSR Academy of Sciences and the Meteor meteorological satellite participated in this experiment.

"Continued study of the physical characteristics of near-Earth space was advanced during the flight of spacecraft Soyuz-9. Cosmonauts made wide use of celestial bodies as reference points in developing methods and new systems of astronavigation and

maneuvering. In performing the numerous maneuvers, orientations, and stabilization of the spacecraft in space, techniques of controlling the spacecraft in different flight regimes were worked out ..."

Alongside me on the table was the logbook. This was a quite heavy volume, weighty and swollen from entries. In it was everything that we had done and observed. Here were our considerations, commentaries, commemorative and explanatory chartings, suggestions, and conclusions. Here in more detailed form was collected what had been listed in the TASS report on the work we had done.

"...The most important part of the flight was the broad medical-biological research on the effect of factors of prolonged space flight on the human organism. Here special attention was given to measures on the conservation and maintenance of a good functional condition of the organism and a high level of cosmonaut work capacity.

"During the extensive medical-biological program, using various functional and psychophysiological tests, the cosmonauts studied their cardiovascular system, functions of external respiration, gas exchange, and energy expenditure, the contrast sensitivity of their eyes, the functions of the vestibular apparatus, and muscle-joint and pain sensitivity.

"During the 18-day flight, continuous medical monitoring of the health of the cosmonauts was carried out for timely diagnosis of possible unfavorable changes in the physiological functions of the organism. The monitoring system included various techniques: observation of crew members in television transmission sessions, radio conversations, reports from the cosmonauts themselves, analysis of the experiments they performed, and, especially, data /213
of telemetry information on the dynamics of their physiological indicators.

"Daily, at the beginning and at the close of the workday, the cosmonauts conducted mutual medical monitoring, during which they measured their arterial pressure and recorded pulse rate and respiration. Similar measurements were conducted before and after performing the planned complex of goal-oriented calisthenics. In addition, maintenance of normal vitality and preservation of high work capacity of the cosmonauts in orbit was ensured by a rational regime of work, rest, and regular nutrition.

"The medical data obtained via telemetry channels, the results of self- and mutual monitoring of crew members, and data from the television observation of the cosmonauts indicate that in a short time they adapted to weightlessness and thereupon well tolerated the complex exposure to the factors of the prolonged space flight, while preserving a high level of work capacity.

"The ground command and measuring complex service and the research vessels of the USSR Academy of Sciences located in different parts of the World Ocean ensured a well-defined and interruption-free tracking of the course of the flight. Continuous radio and television communication was maintained with the spacecraft, and telemetry information was received and processed on an operational basis.

"The craft system and the scientific instrumentation throughout the entire many-day flight functioned flawlessly, providing normal conditions for work and rest approximating Earth conditions in the living compartments.

"After completing the space flight, cosmonauts A.G. Nikolayev and V.I. Sevast'yanov will undergo careful medical examination for some time.

"The prolonged space flight was concluded successfully. The experimental studies performed by the cosmonauts Nikolayev and Sevast'yanov are of great value in advancing space technology and in resolving the practical problems in the building and operating of long-term orbital stations for scientific and national-economic purposes."

Thus, the space flight came to an end. But ahead of us there were many earthly matters associated with this flight. We had to sum up all that we had done and observed in space. We had to write a report. /214

It seemed to me that this part of the work was not much easier than what we had done in orbit. More exactly, it was no less critical. The point was that our report was needed by others who would go on space journeys after us, who would continue blazing a path into the universe. There would be many of them. In fact space is a road without end.

I open up a fresh newspaper issue. On page one is a big notice:

TO SCIENTISTS, DESIGNERS, ENGINEERS, AND WORKERS, TO ALL COLLECTIVES AND ORGANIZATIONS WHO TOOK PART IN PREPARING FOR AND SUCCESSFULLY CARRYING OUT THE EXTENDED FLIGHT OF SPACECRAFT SOYUZ-9.

TO SOVIET COSMONAUTS, COMRADES ANDRIAN GRIGOR'YEVICH NIKOLAYEV AND VITALIY IVANOVICH SEVAST'YANOV.

Dear comrades!

This present anniversary, Leninist year was marked by a new major achievement of Soviet astronautics. An 18-day orbital flight of spacecraft Soyuz-9 was successfully completed. Daring

Soviet cosmonauts, comrades A.G. Nikolayev and V.I. Sevast'yanov, completed the longest flight in space and carried out a great number of scientific-technical investigations and experiments. During the flight the spacecraft equipment and systems functioned reliably, ensuring the faultless execution of the full flight schedule.

A new important step in astronautics was thus taken, signalling the beginning of prolonged manned flight in space. The valuable medical-biological data on the effect of factors in a many-day long space flight on the human organism and work capacity obtained during the investigations, along with the prolonged and comprehensive checking of the ship's technical systems and ground /215
support facilities, and the carrying out of a broad program of scientific and national-economic studies and observations yield necessary practical material that will be taken as the basis of future space flights and will bring the time closer when permanent orbital stations will be built.

The Central Committee of the Communist Party of the Soviet Union, the Presidium of the Supreme Soviet of the USSR and the USSR Council of Ministers warmly congratulate you, dear comrades Andrian Grigor'yevich Nikolayev and Vitaliy Ivanovich Sevast'yanov, on performing your difficult and responsible mission and on the successful completion of the space flight.

We congratulate all the scientists, designers, engineers, technicians, and workers, all the collectives and organizations participating in the preparation, launch, and successful completion of the prolonged orbital flight of manned spacecraft Soyuz-9.

We wish you, dear comrades, further successes in your remarkable work. Let the successes bring new glory to our great socialist Homeland and serve the noble cause of the study and mastery of the universe by man.

CENTRAL COMMITTEE OF THE CPSU	PRESIDIUM OF THE SUPREME SOVIET OF THE USSR	USSR COUNCIL OF MINISTERS

Thank you, many thanks to the Party, government, and to the Supreme Soviet for the high evaluation of our labor. We are ready to do any new assignment!

And here are greetings from the Komsomol:

TO COSMONAUTS OF THE USSR A.G. NIKOLAYEV AND V.I. SEVAST'YANOV

In the name of the Leninist Komsomol, we warmly congratulate you, dear friends, on the successful completion of the outstanding space experiment. We are thrilled by your unparalleled feat and by the display of high self-sacrifice and personal courage. We

are proud that this feat was done by Komsomol graduates, and that the commander of the spacecraft performing the longest space journey had been a delegate to the 16th Congress of the Komsomol. /216

The flight of spacecraft Soyuz-9 -- a great achievement of Soviet science and technology, and the result of the labor of collectives of Soviet scientists, engineers, workers, and technicians -- has become a new landmark in the conquest of space. This is a new outstanding step forward in the advancement of orbital flights and the use of manned spacecraft for solving practical problems of science and the national economy.

Congratulations on your return, heroes of space!

Central Committee of the All-Union Leninist Communist Union of Youth [Komsomol]

And thanks to you, our young friends. There is much that binds us to the Komsomol. As cosmonauts, we hold ourselves to be in service of the Komsomol. We are always glad to meet with young people, to give them our experience, our knowledge ...

* * *

The flight of spacecraft Soyuz-9 had been in the center of attention in the world community and had received high praise from scientists of all countries.

The world press commented widely on the outstanding success of Soviet astronautics and noted its great significance for the further progress of space science.

WARSAW. "The importance of the flight by the Soyuz-9 crew, setting a record for time spent in space, lies above all in that," pointed out Tribuna Liudu, "that it opened up broad prospects for the practice and use of space knowledge in the interests of the growth of the socialist economy, for the good of working people."

BERLIN. "The scientists of the GDR send warm congratulations to their colleagues on the successful completion of the many-day long flight of Soviet spacecraft Soyuz-9," wrote Neues Deutschland.

BUCHAREST. "The record-length space flight of cosmonauts Nikolayev and Sevast'yanov showed that man can remain for long periods in space," announced the republic's coordinator on space research assisted by Earth satellites Professor K. Popovich. /217

HAVANA. The news of the landing of the Soviet spacecraft Soyuz-9 was subject No. 1 on Cuban radio. In a message sent from

Moscow by radio it was noted that cosmonauts Andrian Nikolayev and Vitaliy Sevast'yanov felt well after their 18-day space journey. The radio station stressed that the landing of Soyuz-9 had been successful.

CAIRO. "We are thrilled with the flight of Soyuz-9," said the well-known Egyptian astronomer Professor Adly Soliman. "I just heard on the radio that the landing had been very gentle and precise. Soviet cosmonauts had set a new record for time spent by man in space. This is an enormous scientific achievement. It blazes the path to the building of space stations. We truly rejoice in your successes."

DELHI. The outstanding Indian scientist, planning commission member Doctor V.D. Nag Chaudhuri announced that the flight of Soyuz-9 was a major contribution to space research. The "world record of time spent in space set by Soviet cosmonauts Nikolayev and Sevast'yanov," he emphasized "is not only a remarkable technical achievement, but also proof of the successes that Soviet scientists have achieved along the path of building a permanent space station."

NEW YORK. The report of the successful completion of the flight of spacecraft Soyuz-9 was met with high interest in the United States. Radio and television told about the landing of the spacecraft in the designated area west of Karaganda and how cosmonauts Andrian Nikolayev and Vitaliy Sevast'yanov had felt quite well after their "record flight in space."

The New York Times noted that the Soyuz crew had completed highly important studies, resulting in valuable data on the effect of prolonged space flight in weightlessness on the human organism.

BUDAPEST. "The 18-day flight of Soyuz-9 with Nikolayev and Sevast'yanov on board," wrote the newspaper Nepsabszag, "is of enormous importance in the progress of astronautics above all because it can be considered as a forerunner of inaugural space station." The paper noted the great importance of the observations made during the experiment. /218

SOFIA. The newspaper Rabotnichesko Delo, an organ of the Central Committee of the Bulgarian Communist Party, devoted an editorial to the successful culmination of the Soviet space experiment. The flight of Soyuz-9 has come to be called a working flight, wrote the newspaper. A. Nikolayev and V. Sevast'yanov set out into space as workers in order to work and live there for a long time. Data of this space marathon are being carefully studied and processed. But the first important conclusion was already reached -- man can remain in weightlessness for long periods while preserving his work capacity.

PRAGUE. Newspapers of the Czechoslovak capital reported today in their leading columns under large banners the successful completion of the flight of Soviet spacecraft Soyuz-9 around the Earth.

"Bridge to the stars" is how the Moscow correspondent of Rude Prava wrote in an article bearing this heading, describing how the Soyuz-9 flight is a new step in the Soviet space program. The just completed complex spacecraft flight in its programming results represents a new pillar of the Soviet bridge to other planets of the solar system.

PARIS. Today the entire Paris press extensively commented on the completion of the Soyuz-9 flight.

Paris-Jour maintains that the "flight of Soyuz-9 opened the way to building orbital stations where man can reside and work for long periods."

The scientific observer of the France Press Agence pointed out that "from the medical standpoint, never before have space medical specialists had such a wealth of data recorded over a nearly 3-week period dealing with the physiological and psychological condition of man in a state of weightlessness."

VIENNA. "A tremendous contribution to science," "The longest space flight," "All systems functioned flawlessly," "After 18 days' flight -- a perfect landing," -- under these headings Austrian newspapers reported in their leading columns on the conclusion of the flight of Soviet cosmonauts Andrian Nikolayev and Vitaliy Sevast'yanov on the Soyuz-9 spacecraft. /219

The newspaper Volkstimme noted that the flight of the Soviet cosmonauts was "an important step on the path to building long-term orbital space stations."

TOKYO. "A record for time spent in space," "Flight program completed in full" -- today's newspapers reported, under these banners, on the successful completion of the flight of the spacecraft Soyuz-9.

"The long successful flight of Soyuz showed," wrote the newspaper Mainichi "that the Soviet Union successfully solved the problem of building an orbital station in space."

ROME. "Breaking all records, Soyuz-9 returned to Earth" -- this is the heading under which the newspaper L'unita reported on the successful completion of the flight of the Soviet spacecraft.

"Slowly and reliably, like an elevator, Soyuz-9 descended to Earth," under this heading the newspaper Paese Sera reported on the completion of the flight by cosmonauts Nikolayev and Sevast'yanov.

The pile of newspapers on our beds grew threateningly. For nearly 20 days we had not read any and now we threw ourselves on them like hungry wolves on their prey... And only the arrival of physicians and their invitation to supper interrupted our "newspaper banquet"...

Evening, after dinner, our wives and daughters came to us. Vitaliy went to his room with his family, and we remained together, the three of us. I gave to Alenka and Valentina souvenirs brought back from space. To Alena I gave her doll and a little booklet written on her birthday, 8 June, and also a picture postcard of Vitaliy's with a view of Lake Baykal, with a line written by him, while to Valentina I gave verses by Rasul Gamzatov and Aleksandr Blok, photographs with inscriptions taken during the space flight, and also pens, pencils, other objects of our "space" custom. /220

Our time has passed imperceptibly. We have to lay down to sleep. Alena with Valentina and Natasha with Alevtina, on bidding goodbye to us, leave for home. Only our physicians Nikolay Alexandrovich and Vasiliy Alekseyevich remain, who were always with us in the clinic, gave us a great deal of attention, and were concerned with us, assisting us in everything we did. Before going to sleep they again measured our pulse, blood pressure, and temperature. The data showed no special changes, although we did feel somewhat better. The heaviness of our weight felt less, already by half a unit, however we were healthily fatigued for the day, as if we had unloaded a railcar full of firewood.

Comfortably settling into bed, we soon fell asleep.

21 June, workday, began at 7:00 in the morning. The physicians took our pulse, blood pressure, and body temperature. After the night's rest the parameters had improved somewhat. Under the plan, the specialist physicians began our next examination. The following procedures were part of the plan:

-- study of our basic gas exchange (analysis of exhaled air);

-- taking blood from our finger for clinical analysis;

-- taking venous blood for biochemical analysis;

-- water load for determining renal function;

-- roentgenological and ultrasonic studies of bone density;

-- study of neuromuscular apparatus;

-- psychological tests;

-- unipolar and bipolar test with polyeffector recording of functions for determining the biological activity of the brain;

-- experimental-psychological investigation: stability of assigned activity with respect to interferences in signals in a study of the volume and distribution of attention in short-term memory, dynamics of sensomotor (sensory-motor) reactions with polyeffector recording of physiological functions in the study of simple motor reactions, and the reaction of selection of acoustic stimuli; /221

-- time test: simple -- 20-sec and involved -- with assigned 5-min activity in order to determine the perception of time in simple and complicated conditions;

-- solving verbal problems in order to study higher nervous activity;

-- carrying out the "Vertical" experiment in order to ascertain perception of position in space; and

-- collection of saliva sample.

The examination program was concluded only by 7:00 that evening.

On this day we felt much better. Our bodily heaviness was felt even less, and the "g-load" was about 1.2-1.3 units. True, when I inclined my head, my body still leaned in the same direction in which my head was tipped. However, this now was not as noticeable as on the first day.

That evening we again had guests -- Alena with Valentina, and we again conversed for a long while.

Before bed there were the regular examinations. This night I slept well. I even dreamed. I dreamed of the space flight. It was as if I was in the space ship and I did not know from where the black spot over me had been taken. On awakening, I came to myself only after half a minute, coming to understand that I was in bed, in the clinic, and that the black spot was a picture which hung on the wall over my bed.

23 June. We woke early. It was a fine sunny morning. I had slept well. After rising, I was again weighed, then began the scheduled work. The examination by the specialist physicians, the electrogastrography, the "Vertical" experiment, and cyclography. Next came a general and local massage. Here the emphasis was given to the muscles of the legs and back, whose tone proved to be the most depressed. Speaking frankly, the massage was the most pleasant procedure for us, during which time the fatigue was relieved and my whole body felt good.

Then we were examined by Full Member of the Academy of Medical Sciences Professor Nikolay Semenovich Molchanov and Full Member of the Academy of Medical Sciences, Professor Aleksandr Aleksandrovich Vishnevskiy. /222

On hearing our story of the difficulties in adapting to Earth conditions and of our first sensations after landing, Aleksandr Aleksandrovich Vishnevskiy jokingly said, "Perhaps then weightlessness actually is the normal state for man, and perhaps people came to Earth frome space?"

This day was also memorable for us in that for the first time the doctors let us engage in morning calisthenics and in the evening -- a short walk.

The changes in the functional condition of our organism determined the kind of organization and the choice of means and methods of physical conditioning in the recovery period.

Beginning on the fourth day, the day's agenda included morning hygienic gymnastics, one feature of which was performing exercises in the horizontal position and when sitting. Later, the exercising included general conditioners with gradual buildup in their number of repetitions and pace.

Evenings we began to take short walks, and by the tenth day the walks were extended to an hour.

After the walks we still felt fatigue in our leg muscles, our pulse rate quickened, but when we climbed up the staircase to the third floor our pulse rate rose to 120 beats per minute. Before bed the pulse rate dropped to 86-90 per minute, and the systolic blood pressure was 125-130 mm Hg.

Sleep completely relieved our fatigue, our pulse rate became normal, 68-72 beats per minute, and our blood pressure was 115/70.

The concluding postflight examinations, on the tenth and twenty-second day, showed that the indicators of force stamina, coordination of motions, and muscle tone began to be close to our initial indicators. Thus, the use of therapeutic physical-cultural measures in a complex with other recovery means promoted normalization of the physical state of our organisms.

The results of the postflight examination showed the favorable effect of physical exercises on our organism, although it did not entirely relieve the adverse effect of space flight factors -- orthostatic stability and coordination of motions were depressed, the strength and size of muscles, especially the antigravity musculature, was reduced, and so on. /223

But in spite of this, the first experiment in a multi-day-long flight showed the soundness of the chosen principles and methods of setting up measures in physical conditioning before and after a flight.

On 24 June we met with the chairman and the members of the State Commission, with leading designers, specialists, cosmonauts, and physicians. The meeting was held in a large hall. We were isolated from all those present by a glass wall. In our small room there was a table with microphones and a telephone and two chairs.

We were isolated from those around us because the physicians feared for us, since our organisms were still weakened and susceptible to infections.

Vitaliy and I reported to the State Commission on the completion of the program of the 18-day space flight and answered the numerous questions of commission members, designers, specialists, and cosmonauts.

After a short rest we again were invited to the same room to meet with journalists, but whereas the conversation with the members of the State Commission were conducted on narrowly specialized subjects, in the talk with the journalists we covered a range of general questions which in fact I would like to recount.

The first question came from the Krasnaya Zvezda [Red Star] correspondent.

"Andriyan Grigor'yevich! Your first flight on the ship Vostok-3 was completed by just yourself. During this last flight you were a crew commander. What differences in your flight could you notice and how did you get along working with Vitaliy Sevast'yanov?"

Answer: "The first difference was naturally the responsibility not just for myself, but also for my comrade, because I was the commander. We worked smoothly and harmoniously. All the experiments were done by the both of us, in a word, we worked in the closest possible way during the entire 18 days. Being the /224
two of us up there is meant of course that it was lively and more interesting, we could exchange impressions and discuss the results of the experiments."

A question from the Pravda correspondent: "Did you, Andriyan Grigor'yevich, feel any difference due to the years that separated your latest flight from your first launch?"

Answer: "Oh of course I did. Much has happened over the past 8 years. First of all, during this time I gained new knowledge, habits and experience. I graduated from the Air Force

Engineering Academy imeni N.Ye. Zhukovskiy. Secondly, both the flight conditions and missions have changed. During this time the equipment was new, more complicated. We flew 18 days. In space my organism reacted to flight conditions about as on the first flight. However this time I was exposed to all space flight factors for a longer period. So after landing my sensations were entirely different. The transition back to Earth conditions, that is, readaptation, was more complicated. Even now, 6 days later, it seems that I still feel some g-load."

A question from the Komsomol'skaya Pravda correspondent: "Space flight has its own difficulties: weightlessness and being in a confined space. What did you dream about more, when thinking about Earth, what did you wish for? About what earthly subject did you think about?"

Vitaliy answered this: "With all the strenuous schedules of the space activity, at some moments we thought about our relatives and friends remaining back on Earth. Sometimes we very much wished to go to some Moscow area lawn, to take a walk with my daughter Natasha, and to haul her about on my shoulders."

I added: "I very much wished to be with Alena and Valentina, among my relatives and friends. And I even though how good it would be to wander through the forest with rifle in hand or sit with my fishing rod on the banks of the Volga. We longed for Earth, especially at flight's end. As soon as the ship passed over our country, it was difficult to tear yourself away from the window. In fact, one wished to gaze and gaze at the "solid" Earth, wherever we were crossing it. Nearly two-thirds of the flight route passed over the ocean. And on seeing the native outlines of our land, it was like visiting home."

A question from the All-Union Radio correspondent: "We saw that you have logbooks and notebooks on the table beside you. Really, you not only rested, but worked on something?" /225

Vitaliy: "The desire to work was strong, but contacts with specialists are thus far limited so that we had to make the first conclusions ourselves, we read the entries in the logbook, we pondered over the materials, we added to them, and we are preparing for a more detailed report to the specialists."

I added: "I would wish to say something about all our scientific specialists. Our general feeling is normal. With every passing day, so to say, we are becoming 'earthbound,' although adapting to Earth conditions turned out to be more complicated than we had thought. Somehow the whole body felt heavier, it was hard to get up from a seat, it was hard to raise your hand... But still gradually we are returning to our former condition. We have much of our old strength back, but we still have to put up with some weakness."

A question from the TASS and Novosty Press Agency correspondents: "You have already met with you families. How did they receive your flight? And what did you feel when you met them?"

Answer: "You can say that these meetings were the most pleasant."

TASS correspondent: "What sensation at the flight appeared to you to be the most unexpected."

Answer: "Earth's gravity."

The press conference concluded.

On 25, 26, and 27 June, the medical examination continued. And after dinner free time was allowed us, and we again set to reading the newspapers. There was an article from the chief secretary of the commission on technical-sports problems of cosmonautics of the USSR Federation of Aviation Sport in Krasnaya Zvezda, I.G. Borisenko: "Soyuz-9 records" where, in particular, it read, "during the trip in the space orbit of spacecraft Soyuz-9 spent 424 hours in space and covered a distance of about 12 million kilometers.

"The crew successfully performed an extensive program of scientific-technical and medical-biological studies and also achieved in the working flight four world records, which have been presented for confirmation to the International Aeronautics Federation: two absolute world records for time and distance of space flight and two world records for duration and distance of space flight in the category of multi-manned spacecraft."

These articles thrilled us. Well, well, four world records! /226
These records belong first of all to those who built the ships and the launch vehicles, to those who directed and supported this flight. This is to the credit above all of our heroic Soviet people. These are the records of our great Soviet socialist Homeland.

On the evening after the medical examination had concluded, Vitaliy, myself, and physician Nikolay Aleksandrovich went to the swimming pool in Star City. We had more than once thought about this swimming pool with its steamroom during our flight. While still in space we agreed that after landing the first thing we had to do was go to the steamroom. Our dream came true only on the seventh day after the flight. We couldn't really believe that we finally were going to a real swimming pool. We even went to the steamroom and steamed somewhat. True, we were still not yet entirely fit to steam in the regular way as before the flight, in fact our doctor didn't allow us to remain in the steamroom for long. We washed up good and completely, as they

do on Earth. We got such great satisfaction from the pool that it is even hard to talk about it. We felt altogether light and free and we did not sense even the heaviness of our legs and of our whole bodies. At once our strength mounted and tiredness vanished. It was as if we had been born again. It seemed to us that we were again in weightlessness. We were happy.

28 June was Sunday, our day off. But from morning we prepared for our conversation with specialists. We summed up the results of the work we had done in space. The physicians summed up the results of their examinations.

Some Results of the Medical Examinations

The main aim of the flight of Soyuz-9, as we have already said, was to study the human organism of persons actively working in weightlessness for an extended time. No less important a mission was the subsequent study of the transition of a person after prolonged residence in weightlessness to conditions in Earth's gravity.

What then did the postflight studies reveal?

First, they showed that a combination and adaptation of the human organism to the new conditions of space flight, to weightlessness proceed much faster than the reverse combination and adaptation after prolonged residence in weightlessness, back to Earth conditions, to conditions of Earth's gravity. /227

Secondly, they showed that prolonged residence in weightlessness very strongly affects the vital activity of the human organism, that extremely significant changes occur in it which require an extended time for recovery to the former normal state.

Thus, from the data of the roentgenological examination, during the flight heart size and volume decreased 10-12%. The reduction in heart size occurred evidently due to inadequate physical load which the heart experienced in the state of weightlessness.

The results of studying the neuromuscular system showed that prolonged residence in the state of weightlessness and confinement in movements lower muscle force, and lead to atrophy of muscles and poor coordination of motions. But muscle recovery proceeds slowly. Five days after landing we still felt pains in the muscles of our legs and in our back. These pains disappeared only by the tenth day.

The volume of the muscles of the legs decreased during the flight: the knee became 1-2 cm thinner and the thighs became

2-4 cm thinner. Their tone decreased markedly, as did the exercise station strength. But the strength of the wrist flexors remained unchanged. These changes occurred evidently because in weightlessness the legs played a passive role, that is, they received nearly no load except for the 2-hour long physical exercise period. But the hands were continually engaged and were work-loaded. We did absolutely everything with our hands, therefore the tone of the muscles of the hands and their flexor strength remained nearly unchanged.

The loss of body weight was evidently due to both dehydration and some atrophy of muscle tissue and reduction of fat tissue.

The studies showed that muscle tone, a major mechanism of regulation of the organism in weightlessness, underwent some modification.

In order to prevent changes in muscle and other disturbances in future flights, evidently it will be essential to more intensively apply physical exercises and to provide the necessary loads on the muscles of the entire organism, especially on the musculature of the legs.

Scientists hold a view that the accommodation of the organism /228
to Earth's conditions will depend on the duration of the residence in space flight (weightlessness), that is, the better the organism adapts to weightlessness, the more arduous and longer will be the readaptation.

Actually, after the first 4-day flight on Vostok-3 I felt nearly no sense of readaptation and did not feel the heaviness that I experienced after the 18-day flight.

Evidently, in 4 days the organism is not yet able to readapt to weightlessness, therefore after return the organism rapidly enters conditions familar to it.

During the 18 days of the flight on Soyuz-9 our organism was able to fully adapt to the conditions new to it. And after returning it actually was difficult for the organism again to readapt to the conditions of Earth gravity.

Thus, careful medical examination immediately after landing and for an extended time yielded valuable data on the adaptability of the human organism to ordinary conditions of Earth existence after prolonged residence in a state of weightlessness. The functional activity of the organism became generally normalized by the tenth day after the flight, without pathological residual effects. However, increased fatiguability and reduced work capacity persisted even longer.

The 18-day flight on Soyuz-9 confirmed the possibility of prolonged residence in weightlessness and the good work capacity of man in space. Of course, this necessitated careful preparation and applying preventive measures against weakening of the organisms by prolonged weightlessness.

Today we have some experience in overcoming the barrier of prolonged weightlessness. Short flights lasting 1 or 2 weeks can evidently be carried out without any additional intervention in the human organism. The cosmonaut has enough strength, habits, and stability acquired during ground preparation for these flights.

For flights of moderate duration -- several weeks or months -- it is best to prevent the organism from weakening by employing /229 systematic physical loads. For this purpose, a special motor regime is needed for physical loading of the muscle apparatus and the cardiovascular system. Specialists must develop techniques and methods of the physical conditioning of the organism in space.

Specialist scientists, drawing on the results of the extended flight on Soyuz-9, set up a system of physiological protection of the organism from weightlessness, which has already been employed on the prolonged orbital station Salyut; there they installed special equipment (treadmill, rubber shock absorbers, a vacuum chamber, and so on). Special load suits were sewn for the crew members. With them, the cosmonauts could daily perform physical exercises and give the organism suitable loading.

Numerous special trainers were also provided on the American Skylab station.

In the future, as experience, techniques, and methods of physical conditioning inflight accumulate, doubtless onboard equipment will be supplemented and perfected.

For space flights of long duration, let us say of a year or several years, and flights of this length are needed for manned flights to Mars, Venus, and other planets of our solar system, it will probably be necessary to resort to providing artificial gravity on space ships. And this can be done by building some kind of rotating system with a large lever arm on the spacecraft, where the crew will live and work for extended periods of time. The force (centrifugal) built up when this system rotates will provide a definite loading. In the view of scientists, the optimal load acting on the human organism must be about one-third Earth gravity.

In prolonged flights, evidently the necessity of giving special attention to preparing the crew organisms for return to Earth will arise. For this purpose, for a certain amount of time before the end of the flight, the muscle tissue of the cosmonauts

can recover on the Earth station base and the organism can be saturated with mineral salts which leave the organism in weightlessness, the cardiovascular system can be prepared, and the organism can be conditioned to tolerate g-loading during the descent of the craft and subsequent readaptation to the gravity of our planet. /230

These are thus far only assumptions, but they are based on results from the 18-day flight on Soyuz-9.

In conclusion, it should be noted that the analysis of crew activity in which several medical-biological and psychophysiological methods of evaluating crew condition in different flight stages and during readaptation showed that crew work capacity was high for the entire flight and by the end of the flight it did not deteriorate. This leads to one of the most important conclusions: man can not only live for extended periods in a space flight, but even work productively.

* * *

The day of 3 July 1971 was specially disturbing for us. In the name of the Central Committee of the CPSU, the Presidium of the Supreme Soviet of the USSR, and the USSR Council of Ministers, a reception was arranged in honor of our crew, scientists, designers, technicians, workers, in fact all those that were responsible for the success of the Soyuz-9 flight.

In the Georgiyevskiy Hall lit by flickering lights in the Great Kremlin palace were assembled the members of the Central Committee of the CPSU, candidates for membership in the Central Committee of the CPSU, members of the Central Revision Commission, ministers, eminent military leaders, representatives of the working people of the capital, cosmonaut-pilots of the USSR, and the leading figures in science and culture.

And even those who built the space equipment came to the Kremlin. The powerful rockets that lift high our interplanetary stations, satellites, and manned crafts are their brainchildren. Along with them, we can say with legitimate pride that the mission of the Party, the Homeland, and the people had been performed successfully.

An atmosphere of a genuinely nationwide holiday reigned in the Great Kremlin palace.

6:00 in the evening. Comrades L.I. Brezhnev, A.M. Kirilenko, A.N. Kosygin, K.T. Mazurov, A.Ya. Pel'she, N.V. Podgornyy, D.S. Polyanskiy, M.A. Suslov, A.N. Shelepin, Yu.V. Andropov, /231 V.V. Grishin, P.N. Demichev, D.A. Kunayev, P.M. Masherov, Sh.R. Rashidov, D.F. Ustinov, V.V. Shcherbitskiy, I.V. Kapitonov, K.F. Katushev, F.D., Kulakov, B.N. Ponomarev, and M.S. Solomentsev

are arriving in the hall. Along with them is the president and prime minister of the United Arab Republic, chairman of the Arab Socialist Union, Gamal Abdel Nasser, and other persons accompanying him. Here are also members of the delegation of the Budapest city committee of the Hungarian Socialist Workers Party headed by Candidate-Member of the Politbureau of the Central Hungarian Socialist Workers Party, First Secretary of the Party, city committee K. Nemet, and other foreign guests.

The reception participants warmly greet the leaders of the Communist Party and of the Soviet government.

A Glinka melody "Glory!" resounds beneath the vaults of the hall.

Vitaliy and I approach in a brisk gait the leaders of the party and the government, to the applause of the audience.

I report to the General Secretary of the Central Committee of the Communist Party of the Soviet Union, Comrade Lenoid Il'ich Brezhnev, to the Chairman of the Presidium of the Supreme Soviet of the USSR, Comrade Nikolay Viktorovich Podgornyy, and to the Chairman of the USSR Council of Ministers, Comrade Aleksey Nikolayevich Kosygin, on the successful performance of the mission of the party and government and on my readiness to perform new missions for the Homeland.

The leaders of the Communist Party, the Soviet government, and the foreign guests warmly and cordially greet and congratulate us on our successful 18-day space flight.

The General Secretary of the Communist Party of the CPSU, Leonid Il'ich Brezhnev, addressed the audience.

"Dear comrades!" he said, "Today we are gathered here in order to warmly greet the heroic crew of spacecraft Soyuz-9 -- ship commander, cosmonaut-pilot and Hero of the Soviet Union, Colonel Andrian Grigor'yevich Nikolayev, and flight engineer, Candidate of Technical Sciences, Vitaliy Ivanovich Sevast'yanov.

"We warmly congratulate the daring heroes on the successful completion of their outstanding space voyage during which they circle our Earth 286 times!

"Never before has anybody spent as much time in space as /232
comrades Nikolayev and Sevast'yanov. This was a test of their stamina and work capacity not only of all ship systems, but above all of the cosmonauts themselves. And we note with tremendous satisfaction that they passed their test with flying colors!

"Time after time after each new flight of the daring cosmonauts we become convinced that man can increasingly more

confidently and with greater mastery enter space. From the romanticism of the first contact with an uncharted world, from the daring challenge to this unfamiliar world, to its dangers, and to the hazards, space flights -- with all the difficulties and risks of this undertaking -- are increasingly entering, so to speak, into the routine of everyday life. They are increasingly becoming first of all a complex and responsible pursuit in the name of science and in the name of the real interests of people. And in this respect the flight of comrades Nikolayev and Sevast'yanov was especially revealing. They manifested themselves not only as daring, courageous, and skillful navigators in the ocean of space, but as selfless workers in space. For 18 days they performed a major and complex program of scientific-technical studies in space as laid out by Soviet scientists. A new major step was taken in the conquest of space; a vital contribution was made to progress in several fields of science and to improving the techniques of space flights.

"But the main result of the flight was a practical demonstration that man can live and work successfully in space, in weightlessness not only for days, but even for weeks. It is a pleasure and a joy to see Andrian Grigor'yevich and Vitaliy Ivanovich after their record long flight in space healthy, full of good spirits, buoyant!

"It is clear to all that this extended space flight required great courage, stamina, and high dedication to duty from its participants. These qualities were manifested in full measure by the sons of our Homeland, brought up by the Communist Party -- ship commander, veteran cosmonaut, Comrade Nikolayev, and flight engineer, junior scientist, Comrade Sevast'yanov.

"I report to you with great satisfaction, comrades, that the Presidium of the Supreme Soviet of the USSR awarded for courage and heroism displayed during the space flight on Soyuz-9 the second medal "Golden Star" to Hero of the Soviet Union, pilot-cosmonaut of the USSR, Comrade Andrian Grigor'yevich Nikolayev. It is also bestowed the military rank of Major General of the Air Force. The title of Hero of the Soviet Union with the Order of Lenin and the Golden Star medal, along with the title "Pilot-Cosmonaut of the USSR" was awarded to Comrade Vitaliy Ivanovich Sevast'yanov. /233

"Allow me, at the request of the Central Committee, the Presidium of the Supreme Soviet, and the USSR Council of Ministers, to warmly congratulate the hero-cosmonauts on the glowing performance of the mission of the party and government and the deserved high awards. We wish them new great successes in working for the good of the fatherland and we wish them good health and happiness."

Nearly every sentence of Leonid Il'ich was interrupted by stormy, prolonged applause.

"Comrades!" he continued. "Thousands of persons participated in building the spacecraft Soyuz-9 and in supporting its flight and the performance of the crew. These are outstanding scientists, designers, and workers, splendid specialists in full command of modern technology, in a word, a great army of thoroughly committed enthusiasts of astronautics. And our thoughts and our emotions of indebtedness and gratitude go out to them, as always in these cases. Their activity finds high esteem in their homeland and among also the people.

"I can say with confidence that the creative thought, the talented hands, and the tireless labor of this remarkable space team of ours will ensure the penetration into the interstellar expanses of new Soviet spacecraft, new exploits of daring Soviet cosmonauts, new discoveries, and new peaceful conquests in space in the interests of science and the national economy.

"Allow me, comrades, to propose a toast: to the glorious crew of spacecraft Soyuz-9 -- to comrades Nikolayev and Sevast'yanov successfully performing the mission of the homeland and deserving of the high awards bestowed on them!

"To all Soviet cosmonauts -- brave sons of our homeland!

"To the ground-based army of the conquerors of space -- to the Soviet scientists, designers, engineers, technicians, and workers, for their great labor so vital to the homeland and all of mankind!

"To new triumphs of the Soviet people in all areas of the building of communism!" /234

And again stormy, heated applause resounded long beneath the vaults of Georgiyevskiy Hall.

Chairman of the Presidium of the Supreme Soviet of the USSR, Nikolay Viktorovich Podgornyy, announced the Decrees of the Presidium of the Supreme Soviet of the USSR on awards given to the Soyuz-9 crew.

"Allow me, dear comrades," said N.V. Podgornyy "in bestowing the high awards of the Soviet government, in the name of those present here, and in the name of all Soviet people to warmly congratulate Andrian Grigor'yevich Nikolayev and Vitaliy Ivanovich Sevast'yanov on the deserved high esteem for their heroism and selfless labor, to wish them new daring and successes to the glory of our great Homeland, the greatest health, and to wish them and their families great personal happiness."

After receiving the high government awards, each of us responded clearly:

"I will serve the Soviet Union!"

The party and governmental leaders warmly congratulated us and wished us health and new successes.

President of the United Arab Republic, Gamal Abdel Nasser, also cordially congratulated us on the high awards of our homeland and in the name of the Egyptian people, referring to the great value of the space flight of Soyuz-9 for progress in science and the mastery of the universe to the beneifit of all mankind. He bestowed on us a high award of the United Arab Republic -- the "Pendant of the Nile" Order. We expressed our deep gratitude to the president of the United Arab Republic and said that we will regard this as recognition of the outstanding merits of the Soviet people in the mastery of space.

Reception participants approached us, foreign diplomats, foreign guests; they congratulated us on the successful completion of the flight and on the high governmental awards.

Along with our fellow cosmonauts, we went up to the scientists, the builders of the spacecraft, systems, and equipment. We saw their shining faces and all this told us of their highest esteem of our labors.

All of us understood well that the flight into space was the /235
tremendous labor of a great many people, from the scientist to the worker, and it is correct to say that all the Soviet people prepared us for the space flight.

Returning from the reception, we saw how Moscow this evening was lit up by the bright fallout of a salute in honor of our heroic Soviet people, confidently moving ahead toward the bright future of communism under the leadership of the wise Leninist Communist Party of the Soviet Union.

* * *

The flight of spacecraft Soyuz-9 stirred tremendous interest around the world. This vibrant interest was shown in the results of the experiment also by the numerous Soviet and foreign journalists gathered on 9 July at a press conference in the auditorium of Moscow State University.

The press conference, devoted to the successful completion of the extended orbital flight of spacecraft Soyuz-9 and a meeting with cosmonaut-pilots of the USSR was organized by the USSR Academy of Sciences and the USSR Ministry of Foreign Affairs.

More than 2000 representatives of the press, motion pictures, radio and television, scientific and public organizations warmly greeted the appearance in the Presidium of eminent Soviet scientists and cosmonaut-pilots of the USSR.

The press conference was opened by remarks from President of the USSR Academy of Sciences, M.V. Keldysh.

I will try to reproduce in this book the nearly full text of the address of M.V. Keldysh and other comrades, for their statements contain a summing up of our flight. Thus, here is M.V. Keldysh.

He spoke about how during the extended space flight the crew successfully performed the complex and extended program of scientific-technical experiments and medical-biological studies.

"The results of this flight," stressed M.V. Keldysh, "are very important for progress in astronautics. The Soviet program of space research is characterized by planned, systematic approach to solving the fundamental scientific-technical problems. One of its directions is the building of extended-term orbital stations for scientific and national-economic purposes. These stations will permit significant expansion of the range of problems under study and the carrying out of new unique scientific-technical experiments. The manned orbital stations will lay the basis for further intensive progress in astronautics."

Further, the President of the USSR Academy of Sciences noted that the flights of the Soyuz spacecraft were the most important stages along this path. During these flights principles of control, maneuvering, docking, and functioning of onboard systems were developed and at the same time integrated missions on the study of our planet from outer space were performed.

M.V. Keldysh said that the direct entry of man into space /236
opened up new possibilities for studying the Earth on a global scale, for the more complete exploitation of natural resources, and for further penetration into the expanses of the universe. To build long-duty orbital stations and for lengthy space flights it is vital to have a consistent accumulation of data on the effect that weightlessness and other space flight factors has on the human organism and on the theoretical possibilities of living and working in space. It is important to have a clear idea of what can be provided by the presence of a cosmonaut on a spacecraft in studying the surface of the Earth, atmosphere, and space, and to find the optimal relations between the functions of man and of automatic devices. This requires prolonged persistent work without which further progress in astronautics is inconceivable.

New important problems were solved during the flight of Soyuz-9. The cosmonauts performed an extensive program of

medical-biological studies on the effect of space flight factors on the human organism in conditions of prolonged residence in orbit. Problems of readaptation of the human organism were studied, along with the effect of weightlessness and reduced muscular activity on metabolic processes, the cardiovascular system, the bone and joint apparatus, and the nature of blood circulation. Interesting results were obtained in an investigation of the dynamic functions of man as part of a control system. This investigation was performed with special cybernetic equipment. A number of medical-biological and psychophysiological methods were used in evaluating the work capacity of the crew in the initial flight stages.

The cosmonauts acquired a wealth of information on the Earth's atmosphere and the processes occurring in it, on the continental and ocean surfaces in different parts of the globe, and on the nature of geological-geographical objects. They continued observations begun by the crews of previous Soviet spacecraft. Thus, cosmonauts Valentina Nikolayeva-Tereshkova and Konstantin Feoktistov photographed the twilight aureole, and its first spectra were obtained on Soyuz-5. The same observations, noted M.V. Keldysh, were conducted during the joint flight of three Soyuz spacecraft in October of last year. Processing of these measurements yielded new interesting data on the optical properties of the atmosphere and on the distribution of aerosol.

The crew of Soyuz-9 also photographed and took spectrometric measurements of the twilight and daytime Earth horizons. The results of these observations will assist in better understanding how the brightness of the atmospheric layer changes altitude-wise and structure-wise. This is important for an exact determination of the horizon line used as a area of reference in the navigation of spacecraft. The cosmonauts also performed a number of other astronavigational experiments.

The combined meteorological experiment in which a Meteor satellite, the Soyuz-9 crew, and the scientific research vessel Akademik Shirshov participated is of high interest. These experiments are vital for meteorologists, for more exact weather forecasting, since they permit an integrated study of the condition of the atmosphere, the surface of the Earth's land area, and the world ocean, and the structure of cloud cover. Investigations made on the Soyuz craft, stressed M.V. Keldysh, contribute greatly /237 to the vital important pursuit of improving weather forecasts.

The anniversary Leninist year of our country of celebrated by new achievements in science, technical progress, and new successes in communist construction.

The general line of the Soviet program of space research, M.V. Keldysh declared in his concluding remarks, is to use the achievements of astronautics for the needs of the national economy

and for scientific-technical progress. The new flight of the Soyuz-9 is an important step along this path.

The President of the Academy warmly congratulated us on the completion of the flight and wished us further success in the noble cause of exploiting space.

M.V. Keldysh reported that the Presidium of the USSR Academy of Sciences has taken note of the outstanding contribution made to astronautics by pilot-cosmonaut of the USSR A.G. Nikolayev, previously honored with the Gold Metal imeni K.E. Tsiolkovskiy, and awarded a Gold Metal imeni K.E. Tsiolkovskiy to pilot-cosmonaut of the USSR V.I. Sevast'yanov.

To the applause of the audience, the medal was handed to V.I. Sevast'yanov.

Remarks were provided by Corresponding Member of the USSR Academy of Sciences O.G. Gazenko.

"The main aim of the medical-biological studies," he said, "was further study of the effect of conditions of prolonged space flight on the functional state of man and his work capacity. For this purpose the functions of the cardiovascular system, respiration, energy outlays, and the condition of the central nervous system and the analyzers were studied. The dynamics of work capacity in performing the corresponding working operations was investigated also based on the evaluation made of the quality of performance in special tests.

"As part of the program of biological studies, several studies with active cosmonaut participation were carried out. The main goal of these studies dealt with the effect of weightlessness on the growth, development, and heredity of different kinds of living organisms.

"The flight of cosmonauts A.G. Nikolayev and V.I. Sevast'yanov convincingly showed that man can not only live for extended periods, but also work effectively in space flight conditions.

"The cosmonauts performed a very broad program of scientific research and as part of it, conducted numerous medical-biological experiments, which as we expect, will make it possible to take a new step forward in studying the effect of weightlessness on the human organism ..."

Further, he presented preliminary results on our condition during flight along with some findings of the postflight examinations.

"Andrian Grigor'yevich and Vitaliy Ivanovich felt fine during the flight. In spite of the heavy workload of the flight program, their work capacity remained at a high level. However,

after performing complicated experiments and the intense workday, they sometimes felt some fatigue, which dissipated completely after a night's rest.

"The highly interesting and valuable observations of the cosmonauts concerning their condition during the flight, along with data of objective examinations, yielded vital information on the adaptation of the human organism in weightlessness. At the beginning of the flight a certain amount of time was required to develop new habits of performing motions, especially when moving around in the ship. But by the third or fourth day of the flight, the locomotion of cosmonauts within the craft was performed with confidence and continuous monitoring of the movements were not required, that is, they were performed automatically.

"The adaptation to weightlessness was manifested also in the indicators of the autonomic system studied. For example, the pulse rate even during the first three to six orbits reached preflight levels and then remained at a lower level. On the third to fourth day of the flight, the pulse rate, breathing rate, and indicators of the electrocardiogram stabilized. The pulse rate of A.G. Nikolayev fluctuated in the range 60-80, while it was 60-70 beats per minute for V.I. Sevast'yanov, naturally rising during the performance of physical exercises, and also several complicated experiments. During sleep periods, the pulse rate dropped somewhat.

"It is interesting to note that in the case of A.G. Nikolayev, compared to his first flight on Vostok-3, during the flight on Soyuz-9 the pulse rate during periods of the day comparable in terms of conditions were somewhat lower. The arterial pressure at rest during the flight remained virtually unchanged. The response of the heart to standard physical load during the flight showed no substantial changes."

Continuing to analyze the preliminary results of the medical-biological observations, O.G. Gazenko said that in the initial phase of the flight, when there were abrupt inclinations of the trunk or head of a cosmonaut, the cosmonaut experienced a sensation similar to what they felt on Earth during vestibular loads, which evidently indicates some decrease in the threshold of initiation of vestibular reactions in weightlessness.

"Their appetite during the flight was good. The thirst sensation proved to be somewhat reduced. The amount of water consumed (considering the water contained in the food) was about 1.6-1.8 liters a day.

"The life support systems of Soyuz-9 strictly maintained the specified conditions in gas composition, temperature, humidity, and pressure of the atmosphere in the craft modules. The cosmonauts were provided nutrition in the form of natural products."

The scientist noted that an important role in maintaining work capacity was played by the rational structuring of working and rest regimes.

"Important data were obtained during postflight observations and examination of the cosmonauts. On the day they landed, pronounced changes in the motor sphere were found in the cosmonauts. Their sensations were similar to what is observed when they were subjected to g-loads on a centrifuge at a level of 2-2.5 units. The head, extremities, and other parts of the body seemed unusually heavy, and the cosmonauts sensed their weight. This condition continued for about 2 to 3 days. Normalization of the statics and motions virtually culminated by the tenth day of time spent on Earth."

The scientist went on to present data characterizing the effect of prolonged weightlessness on muscle tone, on the cardiovascular system, and on blood composition. He noted that changes /239 in physiological functions were generally normalized by 10 days after the flight.

The scientist concluded: adaptation to ordinary conditions of terrestrial existence after prolonged residence in the state of weightlessness occurs with some difficulties and is achieved by a greater stress on physiological systems than adaptation to the condition of weightlessness.

Then I was offered the floor.

In my speech I dwelt on the aims and mission of the flight, preparation of the crew for the flight, and the main problems of carrying out the flight program. Below I present an abridge text of my address.

"The main aim of the flight of Soyuz-9 was studying the prolonged effect on the human organism of space flight factors, and above all of verifying man's ability to function actively in conditions of weightlessness for an extended period of time. No less important an assignment was studying the transition of man after prolonged residence in weightlessness to conditions of Earth's gravity.

"These problems were solved while engaging in an extensive program that embraced a complex of scientific, technical, and medical-biological studies and experiments, such that the following was provided in the program for the further improvement of the ship and its systems:

"developing systems of manual control and orientation as well as methods of applying facilities of autonomous navigation;

"verifying in different regimes the orbital correction system and the system of descent control;

"carrying out several experiments on ship design components (movable mechanical assemblies of windows and other components).

"In the flight we were to perform the following:

"observations of the Earth from space using optical instrument;

"photography of geological-geographical objects for purposes of geological mapping and determining probable regions of mineral deposits;

"observation and photography of atmospheric formations and the boundaries of snow covers; and

"recording phenomena and processes in near-Earth space.

"Prominently included in the program were special medical-biological investigations and experiments for a comprehensive study of prolonged space flight factors on the human organism.

"Before I dwell on the performance of the flight program, I will talk about our living and working conditions, and I will briefly report about changes in Soyuz-9 linked to the program of extended flight, improvement in the working and rest conditions of the crew, and the preparation for the prolonged flight.

"Our preparation for the flight consisted of several stages. At the culminating stage of preparation we prepared for it under the flight program outline. The features of Soyuz-9, its systems /240
of orientation and control of motion, life support system, power support system, and systems for controlling descent and landing were studied most closely. Emphasis in the preparations was placed on mastering and developing techniques of performing the scientific investigations and experiments. In addition, in the course of conditioning crew actions were elaborated in the event that systems in the ship broke down and emergencies developed.

"Much was done in the medical-biological area. General-physical preparation was a large part of it. Emphasis in the organization of this area was placed on developing a complex of physical exercises performed directly on board the spacecraft. They enabled us to preserve high work capacity during the flight and upon our return to Earth.

"We also mastered methods of self- and mutual control of our state of health and providing emergency aid to each other if it became necessary. Since the flight program of Soyuz-9 provided

for working in conditions of altered arrangement of sleep and wakefulness (sleeping during the day and working at night), and in preparing for the flight several measures aimed at readapting the organism to the new diurnal rhythm were used.

"Performing the program on this flight was characterized by a great number of dynamic operations involved with craft orientation. There were several dozen of these operations that we performed. Preliminary orientation of the ship with subsequent stabilization of this attitude by means of gyroscopes was required in carrying out many experiments and observations. As a rule, these orientations and stabilizations were performed manually, sometimes with a conversion to the automatic mode. Nearly daily we performed the so-called rotation of the craft in order to orient the panels of the solar battery toward the Sun. The orientations were performed manually.

"During the flight time we oriented the ship toward Earth on a number of occasions, on being above the shadow side of the Earth. Here we used the automatic, semiautomatic, and manual control modes ...

"During the flight the crew tested a number of devices that were used in the system of orienting and controlling craft motion. In particular, we checked out craft control as it was being oriented toward the Sun at different assigned angles by means of an optical wide-angle indicator ...

"During the flight we corrected our orbit on three occasions. Both manual as well as automatic modes were used. The program provided for and, during the flight, we carried out more than 50 different experiments, and each of these experiments were done several times.

"Under the flight program each of us is assigned different operations and experiments in a definite sequence. We performed most of the experiments independently of each other. But there were many experiments that were conducted jointly. These consisted mainly of experiments requiring definite craft orientation.

"Our work in space proceeded in fairly comfortable conditions: on board Soyuz-9 there was all that we needed for work and rest.

"Our appetites were good throughout the flight and we ate all that was provided for by the routines...

"After completing the flight program on the 18th day, the ship was oriented to provide the retro-thrust. At a set time the descent program was switched on. As the result of firing the retro rocket the orbital velocity of the craft dropped and the craft switched over to an earthward flight trajectory. /241

"After separating the orbital and instrument-equipment modules from the command module, the descent system was switched on. It provided for controlled entry of the craft into the Earth's atmosphere making use of aerodynamic lift ....

"We tolerated the flight well, and, frankly speaking, we did not expect that after landing we would experience difficulties of reverse accommodation to living conditions on Earth or, as the doctors say, readaptation ... Today we feel fine and we are in full health.

"After the 18-day flight of Soyuz-9 we can confidently conclude that in the future man will participate actively in building and operating long-term orbital stations."

Then flight engineer of Soyuz-9, pilot-cosmonaut of the USSR V.I. Sevast'yanov spoke.

"I must report about the operation of the onboard systems," said Vitaliy Ivanovich. "This report will be brief: 'All ship systems and equipment operated routinely,' therefore I will dwell only on several problems.

"The aim of the technical experiments was to test the systems of Soyuz-9 in conditions of prolonged flight, to develop new instruments of the navigation and motion control systems, and to determine the design and dynamic characteristics of the ship and perturbing factors.

"During the flight a new automatic star-orientation sensor was tested. The sensor provided reliable and exact orientation of the craft against the background of bright light interference. The tests made it possible to develop the instrument and to select its optimal characteristics. Testing of a visual optico-electronic device proceeded successfully ...

"Experiments on developing methods and means of autonomous orbital navigation continued. In particular, we determined the period of rotation, measured the flight altitude, and took angular measurements based on ground reference points and on stars... During the flight we developed a method for operational resolution of navigational problems employing onboard computers. This technique can be used for redundancy and increasing the reliability of flight control.

"An entire series of experiments was concerned with studying the design characteristics of the craft. Measurements of craft deformations caused by conditions of vacuum and one-sided heating by the Sun were measured. Inertial characteristics of the craft were refined; moments of inertia and the position of the principal axes of inertia were determined. The functioning of precision mechanisms and optical assemblies in space conditions was studied.

Using optical devices, we determined the precision characteristics of the gyroscopic instruments of the orientation and stabilization systems. Investigation of the nature, dynamics, and brightness characteristics of glowing particles continued, along /242 with testing of high-precision windows ensuring reliable performance of sensors of optical components throughout the flight.

"During the flight the influence of aerodynamic and gravitation perturbing moments on the aerodynamic characteristics and controllability of the craft was evaluated. During the prolonged space flight we fully tested the various crew life support systems."

V.I. Sevast'yanov dwelt further on the medical-biological studies: "The crew performed experiments investigating the functions of the vestibular apparatus, the function of external respiration, the dynamics of arterial pressure, the nature of pain sensitivity of the skin, the contrast sensitivity of the eyes, and the state of preservation of the characteristics of the visual analyzer, muscular force of the hands, and muscle-joint sensitivity.

"All of these experiments were set up not only with the aim of monitoring the condition of the cosmonauts, but principally for a more profound study of the capabilities of man and of all of his organs to function normally during a prolonged space flight.

"To obtain data for building optimal life support systems and also to devise scientifically sound diets and water consumption norms, measurements were made of cosmonaut energy expenditures in the flight conditions.

"At different stages of the flight we performed experiments on the transitional processes of manual control of the spacecraft. These experiments were conducted on a special onboard analog computer with which the various dynamic control regimes were simulated. They enabled us to determine the "transfer function" of man as the main component in a control system.

"During the flight biological experiments were also conducted.

"Much attention was given to experiments that were of national-economic importance. During the flight we repeatedly took observations and made photographs in studying the spatial structure of clouds, determining the boundaries of snow cover, detecting sand storms, storms, and tropical cyclones.

"From Earth we received requests on the state of weather in different parts of the world, performed the appropriate observations, and reported back the results to Earth."

In speaking about photographing geographical and geological objects on the Earth's surface, he noted that revising existing and compiling new geologic maps in searching for minerals were the main aims of this experiment...

Vitaliy Ivanovich spoke briefly on several scientific experiments on near-Earth space.

"In conclusion I wish to note," said Vitaliy Ivanovich, "that we obtained much material during the flight. A detailed study will enable scientists and specialists to move further along in building long-term orbital stations and with fuller knowledge to prepare cosmonauts longer than 18 days and for returning the cosmonauts to Earth in good health and able-bodied."

Then M.V. Keldysh, O.G. Gazenko, V.I. Sevast'yanov and I answered numerous questions from Soviet and foreign journalists, representatives of newspapers, magazines, radio, and television. /243

The first to answer was Corresponding Member of the USSR Academy of Sciences O.G. Gazenko.

Question: "Does the flight of Soyuz-9 mean that the human organism is able to tolerate even longer flights? If yes, then under what conditions?"

Answer: "Flight results afford grounds for assuming that man can tolerate even longer flights."

Question: "Will it be necessary for future permanent orbital stations to be provided with artificial gravity?"

Answer: "How necessary artificial gravity on an orbital station may prove to be it is hard to say right now. This requires several problems to be solved and appropriate experiments, including experiments in orbital flight conditions."

Question: "Will the irregularity of cardiac action of the cosmonauts be reflected in future plans for space mastery?"

Answer: "I must say that the question has not been phrased correctly. No irregularity of heart action was detected in the cosmonauts. But overall the results of the Soyuz-9 flight provide no grounds for modifying plans of future flights."

Then I answered some questions.

Question: "In your report you noted that the flight of Soyuz-9 completed an important stage in the investigation of space. Does this mean that there will no longer be flights around the Earth? And secondly, will women participate in the future in the conquest of space?"

Answer: "Space has just begun to be studied. Much still remains unclear. For example, the effects of space factors on the human organism has not yet been studied fully. So flights around the Earth will continue. As for woman's participation in prolonged flight, I can say this. The duration of flights will increase all the time, and possibly extending to several years. One can imagine what the situation will be on ships if there were just men in the crews."

Question: "Are flights into space now a sensation?"

Answer: "Today it is difficult to surprise people with space flights. Yes, the first Earth satellite was a sensation, the first manned flight into space, the first flight to the Moon. In the future perhaps there may be sensational flights, let us say, flights to other planets and other worlds. But today people on Earth are going into space to work, to study it carefully for the benefit of all mankind."

Question: "To what extent did your first flight help you now, during the extended flight on Soyuz-9?"

Answer: "If I could speak at length, then I could talk for a long time on how the first flight helped me. But in brief I can say that the first flight into space helped me in every way: in preparing for completing this responsible mission as well as for the flight itself. For example, to some extent I already knew about the effect of weightlessness on my organism. In the ship I quietly got up from my chair and went to work. It appeared to me that cosmonauts must be conditioned and acquire experience in space flights just as pilots do. In fact the more a pilot flies the more experience he has. It's the same way with cosmonauts." /244

Question: "How do you look at it, will your record for flight time in space last?"

Answer: "The point is not in the record. Today we are flying in space to work, for a detailed, comprehensive study of space. In the future we will also fly into space in order to learn more about our Earth and about space."

Question: "How did your everyday conditions in space change since your first flight?"

Answer: "Our daily living conditions on Soyuz have been improved by many times: on the Vostok craft, as you know, cosmonauts flew in pressure suits. In the cabins there was not as much space as on the Soyuz. There was one cosmonaut on a Vostok. All conditions for normal living and working of cosmonauts have been provided on the Soyuz craft.

"On our craft during the entire flight the living conditions were at a high level. The air was clean and we were able to maintain any desired temperature."

Question: "For 18 days you and Sevast'yanov were eye to eye in an enclosed space far from Earth. What were the flight results from the standpoint of psychological compatibility? Was there not an effect on your relationships coming from the difference in your temperaments?"

Answer: "Our psychological compatibility was very good. In Earth conditions we had prepared together for a very long time. We are old friends. We resolved all questions jointly. We helped each other in working with advice and we assisted each other in conducting the experiments. If one person performed an experiment, the other did not sit by with his hands folded. The difference in temperaments, it would appear to me, rather helped. If he were taciturn, like myself, then we would have been silent the whole flight. But he was more voluble."

Question: "Did the television equipment on Soyuz-9 permit transmitting color images from space?"

Answer: "Soyuz-9 was equipped with a black and white television camera. But if it will be necessary to send color transmissions from space, then a color transmitter can be placed on board the craft."

Question: "Thus far you are our only cosmonaut who has experienced two kinds of descent from orbit -- ballistic (Vostok-3) and controlled (Soyuz-9). Could you compare your sensations on these variants of return to Earth?"

Answer: "Yes, here there is a great difference. On Vostok the descent was ballistic and the g-loads were up to 8-9 units. The actual process of reentry into the dense atmospheric layers was then quite different. And it was very plain to see that the outer skin of the ship 'burned.' But this did not happen on Soyuz-9. In fact with controlled descent the g-loads and heating of the ship were less than during ballistic descent. The aerodynamic lift of the ship was used on Soyuz. The g-loads were small, from 3 to 4 units. During the return, much could be observed through the window. Vitaliy Ivanovich sat alongside the right window, and he could clearly see the turning of the ship. We presented a report -- we noted when and what commands were given, and when the parachute deployed. We reported about all of this to Earth down to the actual moment of landing." /245

Flight engineer V.I. Sevast'yanov answered the next group of questions.

Question: "What were the life-support reserves on Soyuz-9? How much time could you have continued your flight? When will life-support reserves be provided on a spacecraft for 50 months?"

Answer: "According to the program the flight was to have continued 18 days. We could have flown even longer. It is difficult to say when life-support systems designed for 50 months will appear. Work in this area is underway."

Question: "Do you believe that you will participate again in an extended flight?"

Answer: "I would be happy to go into space once again."

Question: "In flying over the different continents of the Earth, did you observe any difference in the color of the vegetation of the taiga, jungles, and steppes?"

Answer: "Yes, we did observe a difference. From the standpoint of spectral characteristics, the color of the landscapes appeared just as they usually do from an aircraft."

Question: "Did this color change in relation to the angle of observation and illumination by sunlight?"

Answer: "Doubtless, and it did so very strongly."

Question: "When the ship entered the radio-blackout region, did you observe an abrupt cutoff of communications or signals from ground stations or did the intensity of the signals of the ground stations decrease gradually?"

Answer: "The signal faded gradually."

Question: "Is communication with Earth possible on short wave from the radio-blackout region?"

Answer: "Yes, it is possible."

Question: "How close did the Soyuz-9 flight bring closer the solution of the puzzles of weightlessness?"

Answer: "This was one of the stages in conquest of space. And it is making a substantial contribution to the analysis of the prolonged residence of man in conditions of weightlessness."

Question: "How was the time spent in weightlessness reflected in your organism? How do you feel?"

Answer: "How do I feel? You really can see for yourself, I feel fine." /246

Hungarian journalists asked Vitaliy Ivanovich this question:

"Comrade Sevast'yanov, it was pleasant to listen to how, in talking to the members of the Hungarian delegation at the Kremlin reception, you said a few words in Hungarian. How did you come to learn Hungarian?"

In answering him, V.I. Sevast'yanov said: "I had occasion to be part of a student delegation to Budapest. I have quite a few friends there. That is where I got my knowledge of Hungarian."

Question: "What do you wish to tell those who plan to spend extended periods of time in orbit after you?"

Answer: "I would say -- fly, it's very interesting."

After V.I. Sevast'yanov, M.V. Keldysh answered questions.

Question: "What are the next steps in the Soviet Union's space program and when will they be undertaken?"

Answer: "We have repeatedly announced in the press and in press conferences that the main goal that we have set for ourselves for the immediate future is to build orbital stations and to investigate space and the solar system with automatic craft. In addition to this, we will use flights into space for the purposes of the national economy -- for communications, meteorology, navigation, and so on."

Question: "When can we expect a permanent space station to be built?"

Answer: "I believe in the immediate future."

Question: "Is it possible from the experience with Soyuz-9 to determine the maximum possible time that man can spend in space?"

Answer: "I believe that further investigation must be conducted, but the Soyuz-9 experience shows that this flight can be substantial."

Question: "Is the Soviet Union at the present time giving up the landing of man on the Moon?"

Answer: "We never have announced this program so that naturally we cannot abandon it. In the immediate future, as I have already said more than once, we are not planning manned flights to the Moon. Our space program will be just as I have already outlined."

Question: "What next steps in the investigation of space have been prepared and carried out by the launch of Soyuz-9?"

Answer: "Above all this includes several medical-biological problems, gathering material of scientific research essential to the national economy -- geological and meteorological, and others. We believe that the flight of Soyuz-9 is the next major step to building long-term orbital stations."

Question: "The Soyuz-9 spacecraft was launched at night in contrast to the earlier launchings in the morning. What was responsible for this?" /247

Answer: "This was done in order for the landing of the ship to occur during daylight hours, at a convenient time. And this came from the calculations that the flight would be 18 days long."

Question: "The flights of our spacecraft showed that we are in the stage of building permanent orbital stations. Will they consist of several docked Soyuz craft or are scientists developing something different? Will persons in different professions be part of the crews on these space stations?"

Answer: "Obviously, these will be cosmonauts, ship commanders, scientists, persons of different specialties: it is possible that there will be geologists, and definitely astronomers will be part of the crew. As for the relationship of the Soyuz craft to the building of permanent station, naturally all the work on Soyuz craft will be utilized."

Question: "How much time will the cosmonauts spend on the orbital station without returning to Earth, bearing in mind the experience with Soyuz-9?"

Answer: "It is now difficult to give the maximum time, but evidently it is on the order of a month. And this is quite sufficient to have a long-term station because building this station must presuppose carrying out operations in docking and change of crews.

"As to what the physiological limits of man's residence in space are, it is now difficult to say. Still, a knowledge of this question is of great value for interplanetary flights. For example, for the flight to Mars many months will be needed, and during the time of this flight the crew cannot be changed. However, if artificial gravity is produced on a ship, and this is possible, then the time that man can spend in space will be practically unlimited."

Question: "Do you assume that in several years it will be possible to use orbital stations as a launch platform for interplanetary flights?"

Answer: "I must say that the problem of manned interplanetary flights lasting several months is still very difficult. Most likely it will not be solved in this decade."

And thus the press conference came to a close. It showed how great are the prospects opening up before mankind in the age of active penetration of science into the secrets of space.

After the festive reception in the Kremlin and the press conference in Moscow University, we continued long and painstakingly together with specialists in analyzing all of our observation, the results of the investigation and tests, all the entries in the log journals and other flight materials. /248

Much time went into preparing a report on our work in space. At the same time we actively participated in preparing our comrades for the following space flights on the Soyuz-10 and Soyuz-11, for working on the long-term Salyut station, and then on the Soyuz-12 and Soyuz-13 craft.

Our intense work at the Cosmonaut Training Center was sometimes interrupted by trips throughout our country, meetings with workers and kolkhoz farmers, students and scientists, pioneers and schoolchildren. We talked about the preparation of cosmonauts for prolonged flights in space, of the postflight period -- readaptation, about our fellow cosmonauts and about the prospects for advances in astronautics.

After the flight on Vostok-3 in 1962 and after completing the flight on Soyuz-9 in 1970, I had to pay visits to more than 20 countries, and some of them -- two or three times.

I would wish to stress that in any country where the cosmonaut-pilots of the USSR visited, whether socialist or capitalist, where a king or president is in power -- everywhere we were shown the warmest, most friendly reception by all the strata of society -- not only by workers and peasants, but also by state personages and heads of governments. In this I see the tremendous respect of the peoples of the world toward our country, toward our people, admiration for our achievement in economics, science, technology, agriculture, in education, public health, in all areas of life.

In this book I would wish to briefly recount about one of our interesting trips to the United States, for it was devoted to meeting our American colleague astronauts and becoming acquainted with American space technology.

On the invitation of the director of the National Aeronautics and Space Administration (NASA) Thomas Paine, V.I. Sevast'yanov and myself visited the United States 18-28 October 1970.

NASA specialists announced their desire to listen to our /249
reports on the results of our prolonged space flight on Soyuz-9.

The 10-day program of our trip to the United States was aimed mainly at visiting organizations engaged in space affairs and meeting with specialists working in these organizations, and only to a small extent in becoming acquainted with several cities of the United States.

In recounting the trip, I will try to adhere to a chronological sequence of events.

Our IL-62 arrived at John Kennedy International Airport in New York precisely on schedule, at 6:30 p.m. on Sunday 18 October New York time, that is at 1:30 a.m. in the morning, our time, from Sunday to Monday Moscow time.

We were greeted at the airport by the American astronauts Neil Armstrong and Edwin Aldrin who were the first earthmen to step foot on the surface of the Moon. At the meeting were members of our embassy and NASA officials.

At the meeting Neil Armstrong said that he regretted that he had not been able to become acquainted with us during the time he spent in Moscow at Star City. We jokingly answered: at that time we were quite far away -- in space, in Soyuz-9. We expressed our gratitude to Neil for the telegram sent us bearing greeting and wishes for the successful completion of the flight.

After the short meeting, our American colleagues invited us to a small two-engine airplane. And in it we flew to Washington. In an hour we landed at the Washington airport. Here there was a very warm reception. We were met by the acting director of NASA, Dr. George Lowe, NASA representatives, and staff members of the Soviet embassy. We stayed in the Hilton Hotel. Here we became acquainted with astronaut Bill Anders. A friendly supper was organized, served in a warm atmosphere.

On our trip to America we were accommodated by Edwin Aldrin. We noted that an atmosphere of amiable, even more than that, fraternal attitude toward us was shown by our American astronauts throughout our trip.

On the morning of the next day, 19 October, we were received /250
by the mayor of Washington, Walter E. Washington. Then we visited the Smithsonian Institute. In this museum many things are unique. There is the Mercury spacecraft on which Alan Shepherd flew, and there is one of the first unmanned Apollo command modules. Here also is Apollo-11 on which astronauts N. Armstrong, E. Aldrin, and M. Collins flew to the Moon. "A piece" of the Moon weighing about 400 grams is under a glass hood. In the adjoining hall are

aviation exhibits, beginning from the first airplanes and ending with today's models. The experimental supersonic X-15 aircraft on which N. Armstrong flew and which reach now to 210 km is exhibited. With great interest we acquainted ourself with the museum of the history of aviation and astronautics. The we went to Mount Vernon and to the Arlington Cemetery, where we laid wreaths on the graves of astronauts Grissom and Chaffey. Grissom and Chaffey and their friend, astronaut Edward N. White, perished during a fire on the Apollo spacecraft in 1967 at Cape Kennedy. E.N. White is buried at West Point on the grounds of the military academy.

We visited the grave of former U.S. President John Kennedy.

Then we went to the NASA headquarters. We were greeted by deputy director of NASA, Dr. H. Newell. Here also, before dinner, we held our first press conference with representatives of radio, television, and newspapers. Vitaliy and I answered numerous questions.

Then followed the supper. At the supper there were nearly all the official representatives of NASA present. There was the member of the U.S. Senate Fulbright -- "boss in charge of astronautics" as everyone calls him, there were present astronauts Michael Collins -- commander of the lunar orbital Apollo-11, Neil Armstrong, and Edwin Aldrin -- the first earth creatures who stepped foot on Moon, and also accompanying NASA representatives.

It must be said that many American astronauts following their space flights became interested in administrative or political activity. For example, Frank Borman became vice-president of a very large aircraft corporation; Malcolm Scott Carpenter became president of a commercial concern investigating the ocean's resources; John Glenn became a consultant at NASA, and Michael Collins became assistant to the United States Secretary of Commerce. Other examples can be cited. /251

The dinner proceeded in an amiable atmosphere. After the dinner we became acquainted with the historical landmarks of the city. We visited the Lincoln, Jefferson, and Washington memorials. We went to the Capitol, and then we toured Washington's estate, not far from the city. Here he lived and worked many years. The visit left a good impression.

That evening we met with personnel from the Soviet embassy. Vitaliy and myself and American astronaut E. Aldrin were met by children from the embassy bearing flowers. The encounter was very warm. The three of us -- Vitaliy, Aldrin, and myself -- spoke at the embassy with our impressions of our space flights. Then there was an official supper at the embassy, attended by the acting NASA director George Lowe, presidential advisor David, and astronauts N. Armstrong, E. Aldrin, M. Collins, B. Anders, and F. Borman.

On Tuesday 20 October, we flew from Washington on a NASA plane to the city of Huntsville in the state of Alabama. Americans themselves call Huntsville "Rocket City." Huntsville is the location of the largest rocket research center, the "Marshall Research Center." Here during the Second World War was the Redstone Army Arsenal, and after the war military rocket technology began to develop. At that time about 150 German specialists led by Werner von Braun came here. They built rockets, beginning with the Redstone (this is the name of the first ballistic rocket), Jupiter, and Atlas, later named Vanguard. Here also in the "Marshall Center" stages were tested, and then the entire rocket Saturn -- the launch vehicle for the Apollo program. Werner von Braun supervised this center for a long time, but in March 1970 he left to join the long-term programs department of NASA.

Throughout our trip in America we were always accompanied by Edwin Aldrin. At about 11:00 in the morning our plane landed at Huntsville at the Redstone army air base. We were greeted by the director of the Marshall Space Center, the successor of Werner /252
von Braun, Doctor Eberhard Rees, Huntsville mayor Joe Davis, and other official persons.

At the beginning of our visit to the Marshall Center, we became acquainted with the current and future program of American space research. The program provides for continuing Moon research -- the Americans plan to send four more flights to the Moon. The Center is supervising the program of building the Skylab space station. This station was launched into space 3 years later, on 14 May 1973.

We were in the shop where the orbital Skylab laboratory was then being assembled. The station was examined externally, and then we went inside. We were struck by the inclusion in it of a great many different kinds of scientific instrumentation. In the station were two devices for astronaut travel in space. In the living quarters there was a table warmer with magnetic fixation of dishware and table utensils on it during eating sessions. Around the table were three places with restraints for astronaut immobilization. A special room with sleeping bags for three persons was provided for sleeping. In the next room a table was installed on which vacuum securing of objects was being carried out (by suction of air through small openings in the table surface). Here also was located a vacuum chamber and a special fixture for physical exercises -- a bicycle ergometer and other equipment.

Then we were offered the opportunity to become acquainted with the trainer -- the Lunar Rover which was designed to carry astronauts about the lunar surface (beginning with the flight of Apollo-15). Vitaliy and I tried to control this trainer.

Astronaut training consists of developing habits in controlling the lunar trainer as it is being driven over the Moon. The trainer simulates longitudinal and transverse rocking, climbing, and descent of the Lunar Rover and velocity forward and in reverse. The trainee sees the simulated lunar surface on a television screen. On the surface of the "Moon" is plotted the route of the Lunar Rover with numerous turns, rises, and descents. The astronaut must learn to maneuver the car over the given route. Vitaliy and I successfully "drove" on the Lunar Rover. At one of the turns there was in place of the turn indicator, an emblem of our Star City that I had given E. Aldrin as a gift. When I saw our emblem, I knew at once that this was Aldrin's joke. He then explained to us: "I wanted you to feel at home with us on the trainer, just like in Star City." /253

Then we became acquainted with the neutral buoyancy trainer. This is a large swimming pool 25 m in diameter and 13-15 m in depth. A mockup of the modules of the Skylab station is placed in the middle of the pool. Here also we met with astronauts Russell L. Schweickart and Paul J. Weitz, who were training here.

The astronauts preparing to fly on Skylab carried out the related training sessions here under water in hydroweightlessness, utilizing special space suits for this purpose. Technical tests of blocks, installations and systems of the station are also carried out in this same pool.

On the next day, on Wednesday 21 October, before beginning the training sessions in the swimming pool, we studied the pressure suit in detail and worked out the practical maneuvers of a cosmonaut in the pressure suit. Then Vitaliy and Russell underwent medical examinations. Medical sensors were placed on them and they donned their space suits. They underwent final tests and were given their final instructions. Then they went into the pool. Special loads were suspended to the space suit in order that the body be kept in a relatively stable position while in the water. For insurance and to provide emergency aid, Edwin Aldrin lowered himself into the pool in a light diving suit and aqualung.

Together with the instructor, physician, and a translator I went to the command station from where I could clearly see the actions of the astronauts in the pool; here there was also a console for monitoring the overall physical condition of the astronauts, along with radio communications. From here the operation of the crew and medical monitoring of them was carried out. Vitaliy and Schweickart developed procedures for egress from the station into outer space, removed scientific equipment and motion picture film from the surface of the station and brought them to its interior. They worked out operations in securing and releasing their body near work stations and other actions in free floating.

Being at the command console, I continuously maintained radio /254
communications with Vitaliy, I passed on to him the methods specialists' recommendations, I monitored the medical parameters, and I enquired about how he felt. The work was heavy. The pulse of the trainees rose to 150-160 beats per minute. Overall they were underwater for 46 minutes and the scheduled program was completed in full.

After completing the training, Vitaliy reported that the conditions of neutral buoyancy in which he had been were similar to weightlessness that he had experienced on his space flight.

We visited the official museum of rocket and space technology in the state of Alabama. The museum was interesting. Here are exhibited all the spacecraft, lunar module, lunar rover, and all rockets up through Saturn-V. It was very pleasant for us to see a large portrait of Yuriy Gagarin and a mockup of our Vostok that the Americans used in making a film, for the episode in which the Soviet Union sends a ship to rescue the American astronauts.

Before flying from Huntsville, at the Redstone Airbase, we examined the T-38 used for flight training of astronauts. This is a two-seater (with dual control) with a flight velocity of M = 1.5 (one and one-half times the speed of sound) and a flight ceiling of 15-18 km.

The American astronauts on these aircraft, just as Soviet cosmonauts on their own aircraft laboratories, carry out training flights to develop habits essential to the astronaut.

On Wednesday, in the latter half of the day, 21 October, we flew to Houston, Texas, to become acquainted with the Manned Space Flight Center. That evening we were guests in the home of the American astronaut James McDivitt with whom we had become acquainted early in October while still in West Germany at the International Conference of Aviation and Astronautics.

Nearly all the veteran American astronauts with their wives had assembled in his home. It was a very warm meeting. Good humorous conversation flowed at the supper. After the supper, astronaut David Scott invited us to his home where all the beginning astronauts and their wives had assembled. We graciously accepted his invitation and, thanking our hospitable hosts, went to David Scott's home. His home was alongside J. McDivitt's. /255
Here there was just as warm a reception. The American astronauts were just as buoyant and cheerful fellows as the Soviet cosmonauts. We exchanged souvenirs of our meeting.

The "Space Village," as they call the location where they live, is not far from the Manned Space Flight Center. The astronauts' homes were of the two story type, with small yards.

The next day, we were received by the mayor of Houston. Then we became acquainted with the eighth wonder of the world -- a covered stadium accommodating 50,000 spectators. Alongside there was a large exhibition pavilion where an exhibit of different companies that are working on space projects had been organized. Upon inspecting the exhibition, we became acquainted with Werner von Braun. He appeared to be in quite good spirits and was very jovial. He congratulated us on our successful flight.

After examining the exhibit, a press conference was organized, after which we appeared at a session of the American Institute of Aeronautics and Astronauts (AIAA) with reports on several results of the 18-day flight on the Soyuz-9 spacecraft.

Nearly a thousand persons were present at this meeting. As they say, it was the whole "space world." There was the acting director of NASA, George Lowe, the director of the Scientific Center for Development of Manned Spacecraft, Robert Gilruth, Werner von Braun, the Secretary of Transporation, astronauts N. Armstrong, E. Aldrin, T. Stafford, B. Anders, and others. Our reports were heard with great attention and interest. They were simultaneously translated from Russian to English.

On Friday we became acquainted with the Manned Space Flight Center. First we toured the Museum, then we were invited to the trainers. Here they showed us the trainers for the Apollo docking and control and for the lunar landing. After a short familiarization with the trainers, we tried out their control dynamics and logic. In the trainer there was Thomas Stafford as instructor, and a translator. The control dynamics and logic for the lunar module and docking trainer was uncomplicated. The trainer control components were patterned after aircraft control devices, which provided an organic link between flight training on aircraft and habits of working with control devices on spacecraft. /256

Here we tested the trainer designed to develop habits in operating in emergency situations at the stage in which the craft is inserted into orbit.

We were also shown the turboplane trainer. Before his flight to the Moon, N. Armstrong worked out vertical landing on the turboplane.

On becoming acquainted with the Manned Space Flight Center, it should be noted that the flight control group, just as in our country, undergoes advanced training in directing and controlling and actual spacecraft flight.

We were shown the gymnasium where the astronauts trained daily. The gymnasium is spacious and equipped with various training facilities. There is also a Finnish type steamroom in the gymnasium -- a sauna.

In the latter half of the day we were offered the opportunity of sailing on a speedboat, and then of taking an interesting cruise through the Gulf of Mexico on a large yacht.

On Saturday 24 October we flew from the east to the west coasts of the United States. About 2:00 in the afternoon our plane touched down at the Los Angeles International Airport. We were met at the airport by city mayor Bill G. Mills and as a souvenir we were given a key to the city of Los Angeles. In his greetings, Mills expressed the wish that space flight on Soyuz-9 in June 1970 would serve the cause of mutual cooperation and peace and the benefit of the new generation. In conclusion, he invited us: "Enjoy yourselves in our city."

Vitaliy and I expressed our gratitude for the warm reception and the souvenirs.

Here we became acquainted with the Center for the Development of Rockets and Jet Engines at Cal Tech. We inspected a wind tunnel and other test stands.

We became acquainted with the Scientific Research Center for Automatic Spacecraft. At this center projects are being developed, and automatic spacecraft are being built and tested. Here there is also a center for the control of automatic spacecraft. We examined the shops where they are assembled and the museum where there are mockups of all automatic stations. /257

We visited a campus of the University of California. We inspected several laboratories, including a laser technology laboratory. Then we met with the faculty. The meeting was of the question-answer type. There was a small dinner where we met with astronaut Carpenter. It was very pleasant for me to meet with him and after 8 years to thank him personally for the congratulatory telegram that he sent me during my flight on Vostok-3. He cordially congratulated Vitaliy and myself on completing the 18-day flight and wished us success. We thanked him and mutually wished him also health and success.

In Los Angeles we were offered the opportunity of inspecting the amazing childrens' world of Disneyland.

The next day, on Monday 26 October, we bade farewell to hospitable Los Angeles and flew to San Francisco.

Here we visited the largest scientific research center of aeronautics and astronautics. We inspected the powerful sonic and transonic wind tunnels. Tests of aerodynamic characteristics of multiple-use transport supply aircraft (shuttle) type are tested in these tunnels.

We became acquainted with the aircraft flight trainer for pilots, and Vitaliy and I "flew" on it. The trainer closely simulates the entire flight procedures from liftoff to touchdown. This trainer is used for preparing test pilots for flights on new aircraft.

That evening we were guests of the mayor of the city of San Francisco Joseph Alioto.

On Wednesday 27 October we flew to the city of Seattle, in the northwest corner of the United States. We visited the Boeing Corporation.

Here there was a meeting with plant workers. At the meeting the director of Boeing and the mayor of the city of Seattle addressed us with welcoming speeches. We thanked them for the warm greetings and their hospitality. Then we were offered an hour's flight on the new passenger liner Boeing 747, built to hold /258
350-500 passengers. This aircraft is a subsonic aircraft. Its speed is Mach 0.96. Its flight ceiling is 15 km and it has four 20-ton thrust engines.

When we sat in the aircraft cabin, the main test pilot Jack Waddell acquainted us with the cabin installations and instruments.

On liftoff, I guided the aircraft as we gained altitude to level flight, and during level flight Vitaliy took over, while Aldrin took over for the landing.

The aircraft has amazing dimensions externally and internally. The aircraft control was very smooth and convenient and it is very pleasant to fly in it.

After becoming acquainted with Boeing Corporation, we were received by the city mayor. At the reception we were treated to Russian pel'meni and tea from samovars. The waitresses were dressed in well detailed Russian dresses.

On the same day we flew to New York. Our plane touched down late that evening at the John Kennedy International Airport.

The next day, Thursday 28 October, we were received by the mayor of the city of New York. We were shown the sights of the city. We went to the Stock Exchange. The Financiers' Club arranged a dinner for our delegation on Wall Street.

There was a press conference in which representatives of the Soviet embassy, NASA, motion pictures, press, and astronauts participated. At the conclusion of the press conference, they showed our (space-filmed) motion picture, "424 Hours Over the

Planet" -- on the flight of Soyuz-9 -- and we gave it to the American astronauts in the name of the pilot-cosmonauts of the USSR.

On the evening of the same day we flew off to Moscow.

Overall the trip was interesting and took place in an atmosphere of good will.

I wish to recall that all this took place back in 1970. Since then, much has changed. In May 1972, Leonid Il'ich Brezhnev and U.S. President Richard Nixon signed in Moscow an agreement on the cooperation between our countries in the study and mastery of space. It was decided to hold the first joint experiment in space -- the docking of two spacecraft: our Soyuz and the American Apollo.

Mutual meetings of scientists, designers, cosmonauts and astronauts became a regular thing. Docking assembly systems were designed. The spacecraft crews were announced. In our country, these included the veterans Aleksey Leonov, Valeriy Kubasov, Anatoliy Filipchenko and Nikolay Rukavishnikov, along with young cosmonauts, still preparing for their first launches -- Volodya Dzhanibekov, Boris Andreyev, Yura Romanenko, Sasha Ivanochenkov ... /259

The American astronauts preparing for the space meeting are headed by the well-known and experienced General Thomas Stafford.

Already the time of the joint experiment was fixed precisely -- 15 July 1975. Its procedure was as follows: first our Soyuz was to be launched, then in 7-1/2 hours, the Apollo. Then they would dock. The American astronauts would transfer into our ship through a hatch and a special airlock chamber, then our cosmonauts would be the Americans' guests ...

In July 1973 our cosmonauts visited the U.S. Manned Space-Flight Center, where they became acquainted with the Apollo, and in November the American astronauts came to our country, to Star City, where they became acquainted with the Soyuz spacecraft.

I am certain that Soviet and American cosmonauts, scientists, and designers will by their joint efforts write a new page in the study and mastery of space.

What It Means To Be a Cosmonaut

The founder of astronautics, K.E. Tsiolkovskiy, wrote: "I believe in the glowing future of mankind, I believe that mankind not only will inherit the Earth, but also will transform the world of the planets..."

Transform ... Thus it will be. But as of now we are becoming at home in space cautiously and stage by stage. This is being done by scientists, the creators of space rocket equipment, and the persons who began to be called cosmonauts since 12 April 1961. Some ascribe to them the qualities of supermen and place them in the rank of physical exclusivity. Others give them the qualities of some kind of robot and openly refuse to attribute to them any /260
qualities characteristics of ordinary people: they, if you will, lack any kind of emotionality and they do not have curiosity. They are strangers to fatigue. Is this actually what is the case?

I do not know whether I have succeeded, but in this book I have continually wished to show that cosmonauts are ordinary people in general, who by force of circumstances were given an unusual task -- to take the first steps in the mastery of space.

Brilliant minds of the present day, theoretical scientists, designers, and engineers have prepared the springboard for the actual penetration of man into space.

To cosmonauts fell the honor of translating into reality the ideas and dreams of scientists and test the new, unprecedented spacecraft built by designers, engineers, technicians, and workers.

At first fighter pilots began to the selected to test these craft, and then the ranks of the cosmonauts came to include engineers, designers, scientists, and physicians.

The selection was rigorous -- in addition to excellent professional qualities, ideal health was further required.

But as for the other human qualities, in the case of cosmonauts they can be just as widely diverse as among ordinary people. That is why among us there are jovial types and there are people who are sobersided, fastidious. There are voluble types and there are taciturn types. Some are interested in painting, others are amateur movie makers, while still others write poetry. There are inveterate playgoers. There are no less inveterate hunters and fishermen, and all without exception are sportsmen. In short, you can find both physicians and poets among us ...

Sometimes I am asked: do cosmonauts feel fear or is this emotion foreign to them? I can answer this question in different ways. For example, I believe this: there are absolutely no fearless persons, the sensation of fear, or more exactly, the sensation of growing danger is experienced by everyone. Only in some this emotion demoralizes their psyche -- the persons begin to dream and to act irrelevantly and thereby they even further complicate the situation.

In others, this emotions actions as a mobilizing force -- it sharpens all their sensations, all their reactions. The person

finds the right solution and emerges the victor from the unexpected and complicated situation. /261

And here we find cosmonauts included among this latter group.

Chief Designer of the space rocket systems, Academician S.P. Korolev, once said: "Patriotism, daring, modesty, presence of mind in split second calculations, iron will, knowledge, and love of people -- these are determining traits. Without them one cannot be a cosmonaut."

Thus far space flights have been the arena of only a few persons who have undergone very careful training. The molding of the personality of a cosmonaut, the development and reinforcement in him of the essential qualities takes a long time. It is continuous up to the flight and then following its successful completion.

Soviet people are justly proud of the fact that the Soviet Union, whose founding principles were laid by V.I. Lenin, is the birthplace of astronautics. In our country the first concepts of space mastery were born. The first artificial Earth satellite was launched. The first man entering space was the Soviet man Yuriy Gagarin. We were the first to take the most important steps in investigating the planets of the solar system.

The storming of space is essentially a profoundly international undertaking. Even today the fruits of space research are being essentially used by all the peoples of the world. Each flight into space is a voyage after knowledge essential to all mankind. The Soviet Union widely shares its achievements in this area as well. Space cooperation among socialist countries under the Interkosmos program is proceeding successfully. Space collaboration with France is being strengthened. There is an agreement on exchanging scientific information between the USSR Academy of Sciences and the European Organization of Space Research.

Cooperation is developing in this area between scientists of the USSR and India.

In May 1972, an Agreement between the USSR and the United States on Cooperation in Mastery and Use of Space for Peaceful Purposes was signed. It provides for joint experiments in investigating near-Earth space, the Moon, and the planets of the solar system, the environment, space meteorology, biology, and medicine.

All this serves the cause of peace and progress of mankind. /262

Man's role in space research is very great. "The experience of the 'space' years," wrote Yu.A. Gagarin, "confirmed the tremendous role of man in space for the success of scientific research."

The mastery of space has led to the birth of a new profession -- the cosmonaut, and we are correct in singling out the professional activity of persons outside the Earth as a qualitatively new type of purposeful activity with specific methods of operation, work techniques and habits. The pioneer in the new profession, imposing definite requirements on health and physical data of an individual, the profession of daring, all-around trained conquerors of space, was the Soviet fighter pilot Yu.A. Gagarin.

With the increasing broadening and deepening of space research, the significance of this occupation will continue to rise. At the present time there is thus far no clear definition of the profession of cosmonauts, although there are several theoretical comments dealing with the occupational characteristics of cosmonaut activity.

Several Soviet scientists have pointed out that there is much in common between the work done by a pilot and by a cosmonaut. But the specific features of space work, in their view, lie in the fact that the cosmonaut stays for a long time in a closed, limited area of spacecraft and experiences weightlessness.

Thus, Yu. Gagarin wrote:

"The cosmonaut is above all a person whose activities occur in unusual conditions that exert strong effects on his organism, sometimes close to those of his maximum tolerance. The success of a flight that is the culminating stage in the labor of numerous collectives depends on how well the cosmonaut has been prepared for performing his assigned missions."

Several scientists and cosmonauts consider the activity of cosmonauts as a variety of operator work. In the book by A. Leonov and V. Lebedev, Vospriyatiye prostranstva i vremenii v kosmose [Space and Time Perception in Outer Space], it is stated:

"The operator of a spacecraft must perform in parallel several control functions which can be involved with fields of science and technology quite remote from each other. For example, monitoring the performance of equipment of a closed or semi-closed ecological cycle requires biological knowledge, while monitoring flight regime and trajectory requires astronomical and navigation knowledge." /263

The concept of operator activity exactly reflects the place of the cosmonaut in the "man-spacecraft system", and makes it possible to extend basic principles of engineering psychology to the analysis of cosmonaut activity.

The achievements of astronautics in the Soviet Union makes it possible to synthesize improved machines and the outstanding

qualities of the personality of their builder and the Soviet man controlling them.

From the beginning of the program on the Soyuz spacecraft, several investigators pointed to the great significance of scientific research and testing work in cosmonaut activity.

All this leads to the conclusion that the cosmonaut-pilot is a tester-researcher of broad qualifications, whose activity proceeds in unusual conditions.

The cosmonaut-pilot is one of the most multi-faceted of professions. At the present level of progress in space and rocket technology, it is impossible to achieve total specialization in spacecraft crews.

The cosmonaut-pilot monitors the performance of the onboard equipment, controls its operating conditions, performs operations to correct the orbit, docking, and descent from orbit, and also orients the craft to carry out scientific and technical experiments and studies, to provide the optimal conditions for the performance of onboard equipment (for example, rotating for trickle charging of onboard storage batteries).

The role of the cosmonaut in the control of a ship increases with each flight. However, further optimization of the ties between man and the ship systems is required. At the present stage of development of space technology, it is required from cosmonauts as pilots and operators to be able to correctly analyze and operationally make competent decisions. This was confirmed by the flight of Voskhod-2, when cosmonaut-pilots P. Belyayev and A. Leonov took on themselves the craft control, correctly oriented it for landing, and switched on the retro-fire rocket on time and landed the ship. /264

Commanders of the following spacecraft performed complex maneuvers in space: Soyuz-3 -- G. Beregovoy, Soyuz-4 and Soyuz-5 -- V. Shatalov and B. Volynov. They were the first to dock their ships by manual control. Again, V. Shatalov, and then G. Dobrovol'skiy docked their ships to the Salyut space station.

This confirmed the view of specialists that cosmonauts must have flight habits, adequate technical knowledge, self-control, and steady nerves.

At the present time the principal crew activity during a flight is increasingly becoming research-experimental work in the interest of numerous fields of science and technology and also in performing tasks of national-economic significance. During the first space flights of the Soviet Vostok series craft, the main attention was given to studying the tolerance of space flight

conditions by man. Quite a large volume of experiments in science and technology was also performed. They included the following: acquiring data for the study of the physics of the Earth's atmosphere by photographing and observing the Earth's horizon in different illumination conditions; investigating problems of meteor hazard, observing and photographing the Earth's cloud cover for investigating the possibilities of determining various meteorological effects and predicting their development; investigating solar radiation and solar corona, problems of astronavigation, communications, television, and plant and animal growth in weightlessness. Problems of the ability of man to work in weightlessness, his work capacity and sense of well-being in an unimmobilized position, that is during free floating in the craft cabin were studied. Problems of bringing a second craft alongside a first craft at close proximity, joint flight of craft, control of this kind of flight, and simultaneous landing of the craft, along with other problems were explored.

Improvement in space technology, and the growing length of flights predictably adds to the problems in scientific research in space. The present-day spacecraft (station) is a space laboratory. On it, the cosmonaut is still an experimenter, called on to perform a broad program of scientific studies, tests, and medical-biological experiments. Their results will be awaited by dozens of organizations and entire fields of science. /265

During our flight on the Soyuz-9, over the 18 days of the flight a broad program of scientific-technical and medical-biological experiments and studies was carried out. Extensive research work was also performed by the crew of the Salyut space station -- G. Dobrovol'skiy, V. Volkov and V. Patsayev. They worked 24 days in space.

Spacecraft and space stations and their equipment are undergoing continuous improvement. Therefore each flight of a manned spacecraft essentially is a test flight, and the cosmonauts have to still act as testers of this entire space equipment. Their reports and conclusions are vital to progress in astronautics.

The role and significance of scientific-research and testing work in space will rise steadily. Building long-term orbital stations opens up great prospects for further steps in space research. Their application unfolds unbounded possibilities for man's cognition and transformation of the world around him and considerably raises the effectiveness of space investigations and the use of their findings for the needs of the national economy and for scientific-technical progress.

In examining the role of the cosmonaut as an investigator and tester, we must bear in mind that from him, as from no one else, is required objectivity, for the soundness of the scientific findings depends on this.

The cosmonaut must encounter new phenomena unknown to science. He must be able to distinguish this unknown. The process of cognition in a space flight is highly specific, since it proceeds in critical situations, without communications with persons or in the course of communication with a small collective. Therefore the cosmonaut must be scientific worker, he must have creative thinking ability, and he must critically relate to hypotheses, verifying and refining them in practice or rejecting them as invalid.

Man's participation in space flight is growing broadly from year to year. During the time elapsing since the flight of Yuriy Gagarin, several dozen Soviet and American cosmonauts have been in space.

There is not the slightest doubt that in the immediate future, in the next decade dozens and even hundreds of persons will go into space.

Of course, whereas of the nearly 4 billion people on Earth hundreds of thousands of persons have devoted their lives to astronautics and regularly perform (or will perform) flights on spacecraft, it is too early to say that the profession of "cosmonaut" will become a mass profession.

But I am confident that even at the very outset of the third millenium there will be not hundreds, but thousands of persons who will fly in space and work in space.

Let us recall the history of the automobile. In the middle of the past century when the first automobiles appeared, their owners and drivers represented just as negligible a group of people as pilot-cosmonauts and astronauts do today.

Youngsters ran after them in hordes -- as if to control the machine that ran by itself, without a horse! And what speeds! It was simply a marvel! I even read somewhere that there was a debate at that time as to whether man can stand a speed of 30 km/hour.

And now? Today the occupation of driver is one of the broadest. The number of cars on Earth had long gone beyond the 200 million figure. The same kind of story has occurred in aviation. At the beginning of the twentieth century you could count the pilots on the fingers of your hands, but today they number in the hundreds of thousands.

When dozens of orbital laboratories will appear in near space, when the mastery of asteroids and the nearest planets will begin, the number of cosmonauts will increase by hundreds of thousands of times.

Here is when total specialization will in fact become possible -- specialist scientists in different fields of science -- meteorology, astronomy, geology, geodesy... -- will work in the space laboratories.

Forest fire patrols, observers over the migration of schools of fish and the movements of icebergs will fly in space.

The building of large stations in orbit requires large numbers of specialist builders: space installers, welder, and repair workers.

And even our fellow pilot-cosmonaut will pilot scientific space stations and transport and passenger spacecraft. New shifts of scientists on space stations will be supplied, food-stuffs of the stations replenished, new equipment transferred there from Earth, along with building materials and fuel for long-distance spacecraft. /267

And the most experienced of the pilot-cosmonauts will take their ships into distant space. At first to Mars and Venus. Then also to the other planets of the solar system, and beyond...

There is no end to the space road, just as the universe itself is endless.

In solving some problems, mankind is continuously confronting new and even more grandiose problems. There will be no end to the road. Reason is all powerful, it will always triumph...

Our Cosmonaut Team (see photo insert) /268

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Makarov, Oleg Grigor'yevich, Soyuz-12, 1973.
Klimuk, Petr Il'ich, Soyuz-13, 1973.
Lebedev, Valentin Vital'yevich, Soyuz-13, 1973.

Photograph Captions [Numbers refer to penciled number beside each photograph].

Between pages 64-65:

1. 1960. Chief Designer talks to us at length about forthcoming space launches.

2. 1961. After Yuriy's successful landing, we were photographed together as a souvenir.

3. And our training went on. I am in a parachute jump.

4. In the "weightlessness pool."

5. Top -- after a regular flight. Bottom -- on the trainer.

6. Together with Yuriy Gagarin, we are doing road work.

7. A favorite game of all cosmonauts is basketball.

8. We were also water polo enthusiasts.

9. Before the launch, I was able to visit my native Sharshely, and to meet with momma.

10. And now comes my starring hour...

11. In the Kremlin, Leonid Il'ich Brezhnev bestows on me the Hero's Gold Metal.

12. Strolling with Komsomol members, meeting with young heroes of labor.

13. Together with Yuriy Gagarin, I was chosen a delegate to the 14th and 15th Komsomol Congress.

14. On our rare days off, Gherman Titov and I loved to go hunting.

15. We fished with Volodya Shatalov. And sometimes we were lucky...

16. In 1968 we graduated from the Academy imeni Zhukovskiy.

17. We had to complete a large program of research. We became acquainted with the scientific equipment onboard the Soyuz-9.

Between pages 192-193

18. And again begain the training and the endless medical examinations.

19. Vestibular tests...

20. We spent many hours in the trainer cabin.

21. We paid a lot of attention to medical self- and mutual monitoring.

22. We found time also for recreation and I set out for my favorite fishing spot.

23. And again we worked for hours in the trainer.

24. But to everything there comes an end. The moment of farewell approached.

25. We climbed the airplane ramp.

26. Relatives and friends wished us a successful flight and a soft landing.

27. And here Vitaliy and I are at the airport.

28. Our rocket beauty ready for launch.

29. Three, two, one ... launch!

30. Our flight lasted 18 days

31. 8 June 1970, on Alenka's birthday, we met with her over the air waves...

32. And here we are back on native soil.

33. Our first Earth meal.

34. A telephone conversation with Leonid Il'ich Brezhnev.

Between pages 224-225

35. Meetings at the Central Committe of Komsomol. Top -- with L.G. Kosmodem'yanskaya, three times Hero of the Soviet Union, I.M. Kozhedub, and First Secretary of the Central Committee of Komsomol, Yu.M. Tyazhel'nikov.

36. In native Chuvashia.

37. With readers.

38. Viet Nam friends visited us at Star City. First Secretary of the Central Committee of the Party of Viet Nam, Le Tsuan.

39. In Japan. Meeting with Prime Minister Sato.

40. In Mongolia. We are received by Tsedenbal.

41. In Yugoslavia, guests of Joseph Broz Tito.

42. The first music lessons of daughter Alenka...

43. In my native village, guests of momma.

44. Our space team.

45. India. Meeting with D. Nehru and Ghandi.

46. In fraternal Czechoslovakia.

47. Meetings with pioneers of the German Democratic Republic.

48. American astronaut F. Borman as our guest in Star City.

49. On the Soyuz training ship, together with American astronaut B. Anders.

50. Guests of Boeing corporation. In the airliner cabin.

51. At the NASA space center. American cosmonauts tell us about their Apollo flights.

52. I received this letter from A. Aldrin.

53. A group of American astronauts.

54. [Retranslated from the Russian]

NASA
Manned Space Flight Center
Houston, Texas 77058
21 December 1970

To Major General Andriyan Nikolayev, cosmonaut, Star City, USSR

Dear Andriyan!

....Your wonderful visit, I assume, has strengthened the bonds between your country and mine. This of course became possible because Vitaliy and you are such excellent representatives of the Soviet people.

Here, in the Manned Space Flight Center at Houston, we wish that this will serve as one more stimulus for further successful exchange of visits between your cosmonauts and our astronauts.

With heartfelt greetings, I remain truly yours

Edwin E. Aldrin
Colonel, U.S. Air Force
NASA astronaut

55. A worthy generation -- of young cosmonauts -- is growing up in our country.